POWER

Volume 60 New York, July 22, 1924 *No.* 4

The Engineer in the Social Structure

THERE has been a lot of talk lately, and I have done some of it, about the engineer's place in our social economic system.

The engineer's real job, his vocation as distinct from his avocation, is to engineer—to design and build and operate railroads and dams and power plants and steel works and factories and machinery, to determine the properties and limitations of materials and media and search for others that will meet existing or coming needs.

Recent definitions have added the management of men—the organization and direction of the human as well as the mechanical element involved in "the art of directing the great sources of power in nature for the use and convenience of man."

In these capacities the engineer has, with a few notable exceptions, filled an inconspicuous place in the scheme of things and had little to say about, or to do with, the management of public affairs or the making of the rules by which the game is played.

But "the use and convenience of man" have come to depend so much upon mechanical and engineering processes and operations, the sustenance and comfort of the race has come so much to depend upon great correlated engineering enterprises that something more than oratory and political astuteness is necessary for the synchronizing, as Herbert Hoover expresses it, of this gigantic machine built out of the applied sciences.

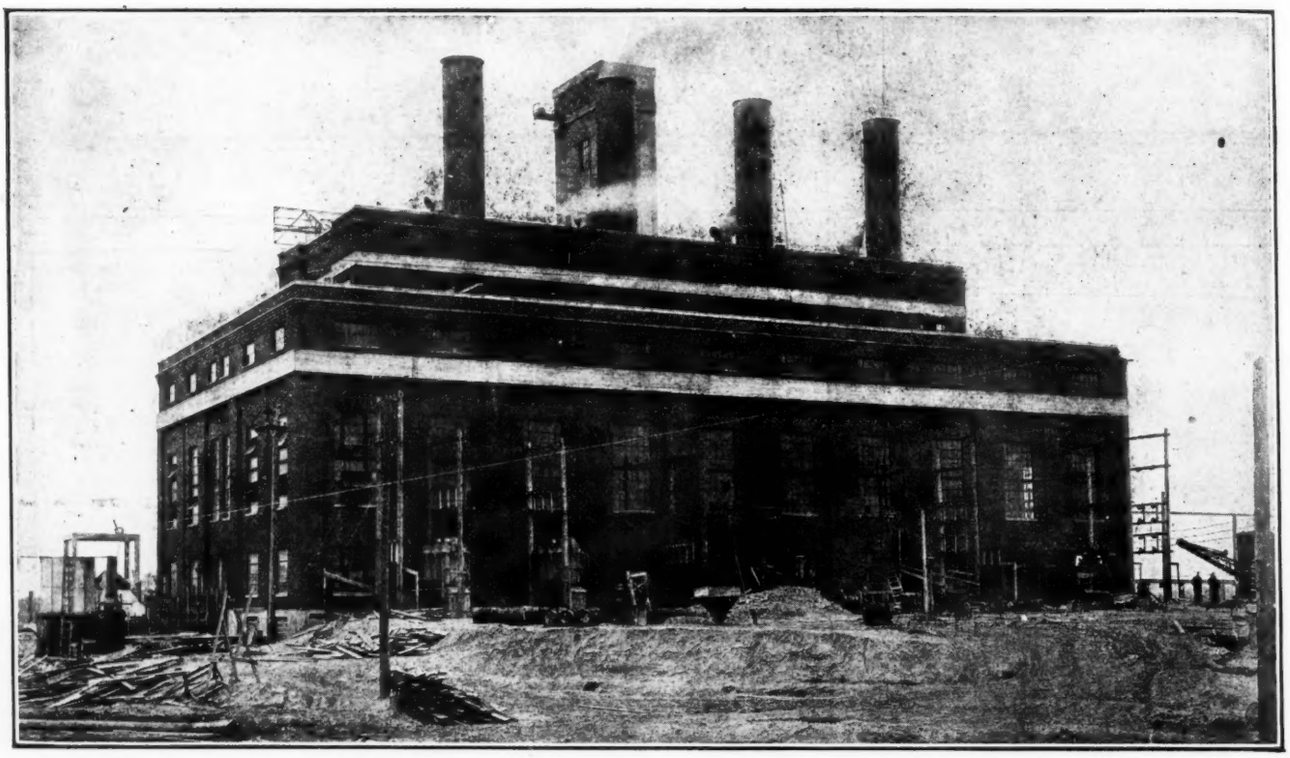
Here is a country of a hundred odd million people. Their needs are fairly constant and determinable. Here is a land with resources in minerals and forests, and ranges and farms, in mills and factories, and railroads, in fuel, steam plants and water power and man power.

There is one best way in which these resources can be developed and fabricated and distributed with the least waste and greatest stability and efficiency so that each shall have a share in the process and a share in the product commensurate with his contribution.

I do not maintain that the engineer has got to throw up his job and go to Congress to get this done, although there might be some straighter thinking in Congress if it had more engineers among its members. I do not maintain that the engineer is necessarily so free from entangling interests, alliances and control as to be always ready to oppose privilege and preference and battle for the public interest whoever may be involved.

But I do maintain that the synchronizing and systematizing of our national housekeeping along safe, sane, rational and scientific lines calls for the application of the unbiased, impersonal, analytical method of the engineer.

And if he will, in his daily thinking, apply these methods to the problems among which we dwell, and will be a living outspoken advocate of the policies that such a process evolves, he will not need to get any further with politics than the ballot box to impress himself and his methods upon the social-economic situation.



Saginaw River power house of Consumers Power Co.

Saginaw River Steam Plant of Consumers Power Company

Initial 40,000-kw. installation of 100,000-kw. plant, featured by preheating of feed water and combustion air with steam bled from three stages of main turbines, conservation of radiated and blowoff heat, water sides in boiler furnaces, sluicing of ashes, and two-motor fan drives. Steam pressure is 375 lb. gage; superheat, 240 deg. F., and final steam temperature, 684 deg. Total plant cost $71 per kilowatt.

ABOUT a year ago preliminary mention was made in these columns of the new steam generating station of the Consumers Power Co. on the Saginaw River at Zilwaukee, four miles north of the City of Saginaw. Construction work had then been started on the initial installation of the plant, consisting of two 20,000-kw. turbo-generators and their complement of four boilers. The first unit was put into operation in March and the second is now ready for operation.

This station is tied in on the eastern leg of the state-wide transmission system of the company, on which there is considerable water-power capacity. It is the plan to utilize the new station as a base-load plant, alternating with the water power. The latter is to be operated at maximum capacity and, when the storage is down, relieved by the new steam station until reserve pondage has been recovered. By proper manipulation the steam plant will thus carry a uniform load at the most economical points on each turbine while it is in use, and with the refinements introduced, it is anticipated that a kilowatt-hour may be produced on 14,000 B.t.u. This is equivalent to one pound of high-grade West Virginia coal such as will be used at the plant.

A feature of the plant worthy of notice is its compactness, the boiler-room floor space being 0.174 sq.ft. per square foot of boiler-heating surface and the turbine room 0.155 sq.ft. per kilowatt of generator rating. From the boiler-room floor to the top of the roof the height is 64 ft. and to the basement floor, 23½ ft. The cubical contents of the boiler room are then 413,952 cu.ft. and including the basement, 565,950 cu.ft., reducing to 11.1 and 15.2 cu.ft. respectively, per square foot of boiler-heating surface. In the turbine room the height from the basement floor to the roof is 67 ft.; the cubical contents, 415,668 cu.ft., and the space per kilowatt of generator rating, 10.4 cu.ft. If comparisons are made, it will be found that these figures are below the average and have had a bearing in keeping down the cost of the plant to the unusually low figure of $71 per kilowatt. This excludes the transmission and land but includes everything else going to make the plant, such as railroads, building, the entire mechanical and electrical equipment, the intake pumping station with circulating water ducts and all overhead, engineering and interest during construction.

The steam-generating equipment in the plant consists of two boilers per turbine, with provision of 0.928 sq.ft. of steam-making surface per kilowatt of generator rating. The steam pressure carried is 375 lb. gage and the superheat 240 deg. F., giving a final steam tem-

perature at the superheater outlet of 682 deg. The boilers are of the cross-drum type, with the stoker under the low end and a setting of unusual height to give a furnace volume of 0.58 cu.ft. per square foot of steam-making surface. An innovation as to design and arrangement is the water-cooled walls, side and rear, which consist of steel tubes passing through cast-iron blocks, taking the place of the usual firebrick. The tubes are connected into the boiler circulation and are therefore under boiler pressure. A superheater of the radiant type is located in the rear wall between the water back and the lower boiler tubes and, with the boiler operating at 200 per cent of rating, is designed to give a superheat of 260 deg. F.

Draft Control Arrangement

From the boiler the gases pass through a low-pressure cast-iron economizer vertically baffled for three passes and having a heating surface about nine-tenths that of the boiler. From the economizer the gases are delivered by an induced-draft fan to a self-supporting unlined steel stack of 8 ft. diameter, rising 60 ft. above the economizer floor and 96 ft. above the firing aisle. These fans are individual units, with a performance as given in the accompanying data. The induced-draft fans have a novel arrangement of motor drive and control. To provide for efficient operation, each fan is equipped with two driving motors, one rated at 40 hp. to operate the fan under normal load conditions and the other at 150 hp. to drive the fan when the boiler is operating at exceptionally high rating. The large motor is direct connected to the fan shaft and the smaller motor by chain drive. Each motor has a controller of the motor-operated drum type, and the two controllers are so connected and interlocked that the manipulation of one push-and-pull switch on the boiler control board will give a wide range of fan speeds. When the maximum point on the drum controller for the small motor has been reached, a contactor cuts this motor off the power circuit, while at the same time the larger motor is energized and will accelerate to maximum speed under its controller, with the small motor coasting. This arrangement eliminates the need for direct-current motors, as with the slip-ring induction motors employed and the control system, the range in speed obtained covers all requirements and the use of the two motors insures economical driving, notwithstanding the greater initial cost. The forced-draft fans have the same plan of control as the induced-draft fans.

The stokers are of the underfeed type, having twelve retorts per boiler with a projected grate area bearing a ratio to the steam-making surface of 1 to 29. The stokers, as well as the double-roll clinker grinders, are driven by the Hele-Shaw hydraulic system. In both the fan and stoker drives alternating-current motors have been used, and this applies to all electric-driven auxiliaries in the plant.

Air for combustion is drawn by the forced-draft fans through an air duct from the space containing the economizers. The air enters this space from the underside of the turbine roof and through louvres opening to the outside above the turbine roof. Provision will be made for heating the incoming outside air when necessary. The air is blown by the forced-draft fans through three stages of air preheaters of the new cellular type to the wind-boxes of the stokers. At the fan the temperature of the air approximates 80 to 100 deg. F. and in the windbox the temperature ranges from 250 to 300 deg. F.

The arrangement of these preheaters is shown in Fig. 3. Hot water from the blowoff tank is to be circulated through the coils of the first stage and discharged to the clear well. Steam is to be introduced into the second stage of the preheater from the eighth-stage nozzle of the main turbine and into the third stage of the preheater from the third-stage nozzle. The feed-water heaters are of the horizontal closed type, and in both cases saturated steam is drawn from the top of the shell. The pressures of the steam from the eighth and third stages of the turbine at 15,000 kw. load and 29 in. vacuum are 19 and 106 lb. abs., respectively. The temperature of the eighth-stage steam

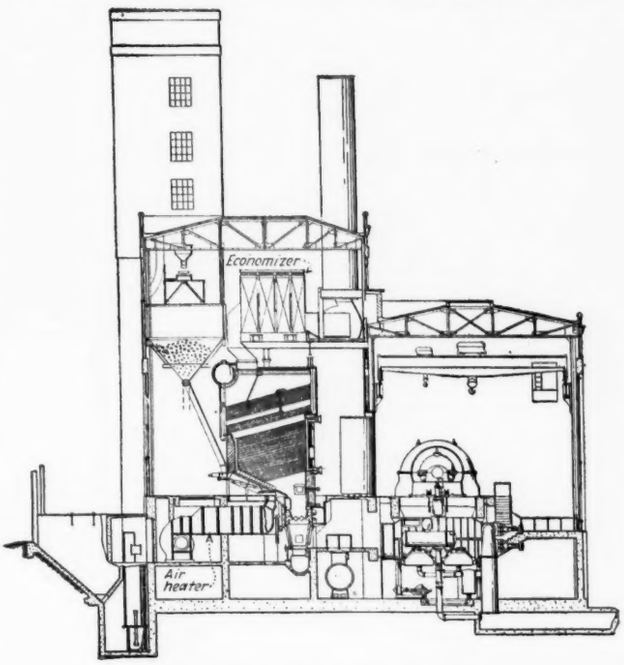


Fig. 1—Elevation through plant

is 225 deg. and of the third stage, counting the 106 deg. of superheat, is 437 deg. F. It should be stated that preheaters for one boiler only are being tried out at the present time, although provision has been made to install the others if the results obtained are satisfactory.

In the diagrammatic drawing, Fig. 4, is shown the connections of the feed-water system, containing three closed heaters, which receive steam bled from the eleventh, eighth and third stages of the main turbine. Evaporators of the horizontal submerged type, with an hourly capacity of 7,600 lb. each at full load or with 80 deg. F. temperature difference are provided, one for each main turbine, to supply pure makeup water, and the system also includes an open heater to utilize the exhaust steam from certain steam-using equipment in the plant, such as the raw-water steam pump and the turbine-driven boiler-feed pump, as well as the flash from the blowoff tank. Raw water is admitted to the open heater under float control in sufficient quantity to supply the feed water to the evaporators. From the open heater delivery is made to the evaporator, steam for which is taken from the eighth-stage bleeder line, and its vapor delivered into the eleventh-stage heater.

Excess condensation, from the condenser and heaters,

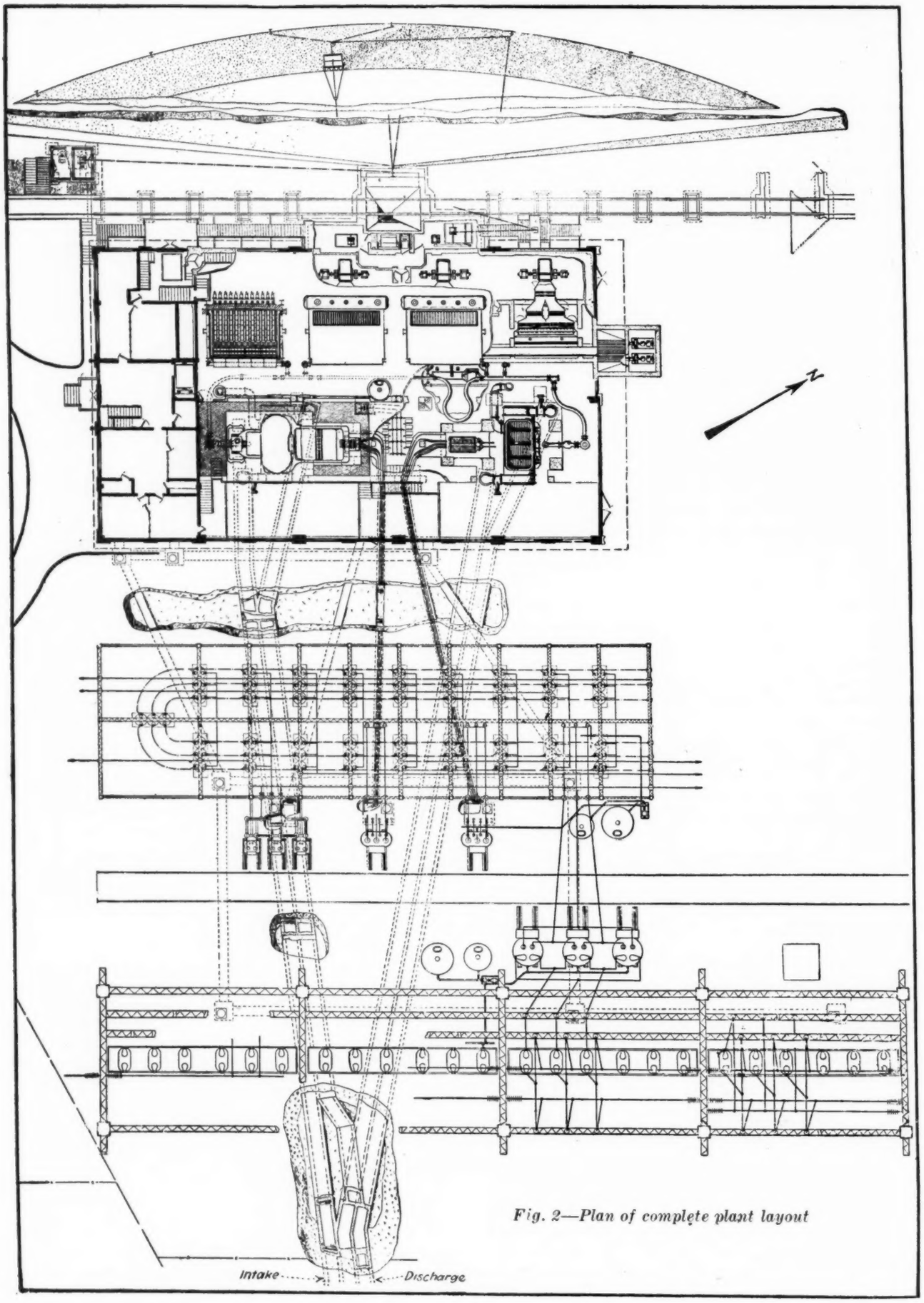


Fig. 2—Plan of complete plant layout

is collected and delivered to a large storage reservoir provided between the foundation walls under the boiler-room basement. The water flows, under float control, from the reservoir to the upper parts of the main condensers through perforated pipes so that the water will be deaërated and in proper condition to pass through the system to the boilers.

The boiler feed is taken from the condenser hotwell by the condensate pump and forced through the first stage of the air cooler for the generator and then through the eleventh- and eighth-stage heaters in series to the economizer pump, which passes it through the economizer and back to the suction of the boiler-feed pump. The delivery is then through the third-stage heater to the boiler-feed mains, of which there are two complete systems, one with automatic regulation, while the other is a hand-operated auxiliary main.

One of the features of the pumping equipment is the arrangement of the boiler feed and economizer pumps on the same shaft. Duplicate pumping units have been installed for the first unit, one driven by a 200-hp. motor and the other by a 235-hp. steam turbine. Each of the pumps has a capacity of 500 gal. per min. For the second unit of the station three pumps have been provided and all are motor driven, the main pumping unit consisting of boiler-feed and economizer pumps assembled on the same shaft and driven by a 200-hp. motor. An auxiliary economizer pump is driven by a 100-hp. motor and the auxiliary boiler-feed pump by a 150-hp. motor.

Raw water for the station is drawn from the condenser intake tunnel by a direct-acting steam-driven pump or by two motor-driven centrifugal pumps, and delivered to the raw-water mains supplying the various services in the plant.

An interesting detail in heat conservation is the provision of an insulated blowndown tank which receives not only the boiler blowdown, but also the economizer relief and blowdown, the blowdown from water columns and water-cooled furnace walls and steam-pipe drips in general. The clean hot water from the tank is to be passed through the furnace air preheaters.

In the plant no high-pressure steam piping has been employed except that supplying the main turbo-generators. By reducing the steam to the auxiliaries to 100 lb. pressure, a big saving in the piping has been effected. The high-pressure piping has been made as simple as possible. The four boilers tap into a 12-in. header with a sectionalizing valve at the center and a horizontal bend to take care of the expansion. From each end of the header the supply lines to each turbine take off. In these lines bent piping has replaced the usual fittings.

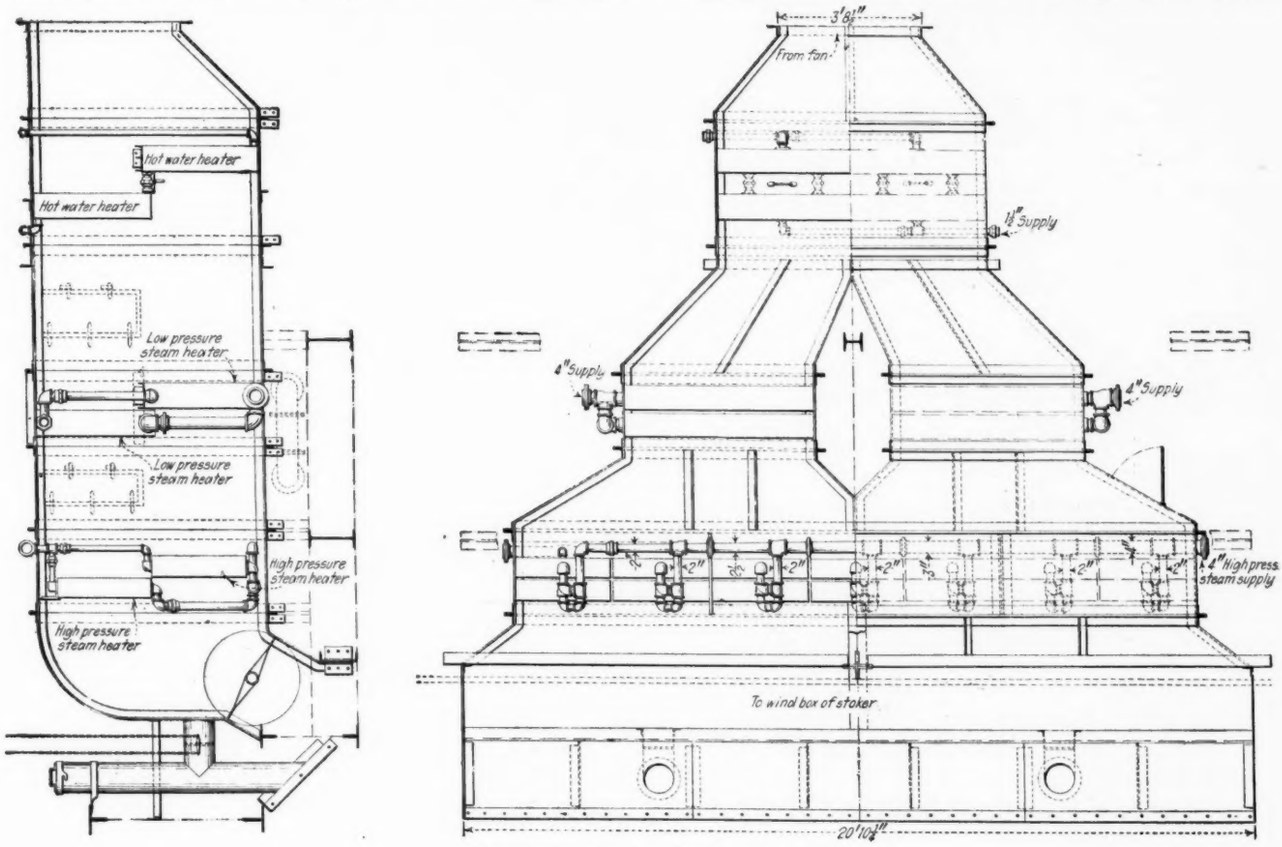


Fig. 3—Preheater for furnace air

When designing the coal-handling system, a layout was made that would require no skilled attention or investment for future plant, and sufficient capacity was provided so that all the fuel could be handled during the day period with two men. Coal is received on a railway trestle and from drop-bottom cars is dumped into a concrete pit located centrally with respect to the four boilers (see Fig. 5). From the concrete pit the coal is loaded automatically into the bucket of a single vertical skip hoist and elevated through a vertical lift of 125 ft. to a hopper in the upper part of the skip tower located outside the power plant and rising approximately 50 ft. above the main roof of the building. From the hopper the coal is delivered through a coal crusher to an automatic scale, or directly to the scale if no crushing is required. Delivery from the hopper may be made also to a spout leading to the yard

storage system. Other arrangements are for delivery of crushed coal either to the scale or to storage.

As the scale is of the automatic drop type and delivers 1,000 lb. per drop, a screw conveyor having deep sides with part of the bottom omitted is placed below the scale to receive the coal and distribute it evenly to a shuttle belt conveyor over the storage bunkers. The conveyor is mounted on a steel frame with flanged rollers traveling on rails. It is about 60 ft. long, or about one-half the length of the boiler room, and is arranged to travel automatically over the bunkers.

The belt is arranged to run in either direction, and when it is desired to fill the second half of the bunkers, its travel, as well as that of the frame, may be reversed. As another alternative, the shuttle belt may be set stationary and deliver into any particular bunker desired.

The bunkers are of steel plates framed into the building steel and lined with 1½ in. of gunite on wire mesh. The total bunker storage for four boilers is about 800 tons. Two bunker outlets are provided per boiler, each fitted with cast-iron rack and pinion gates, chain operated from the boiler-room floor. The delivery spouts from the bunkers are flared to the width of the stoker hopper and provided with guide plates so that mixed coal is supplied evenly to the stokers.

The capacity of the system is 60 tons per hour, and the various units are motor-driven and interlocked electrically for sequence starting and stopping. Push-button control is located near the track level and another control station at the upper level. At present a car puller is provided for handling the loaded and empty cars. To give easy access to the upper system, an electric passenger elevator is provided and equipped with push-button control so that no special operator is required.

Coal, delivered to the yards from the overhead spout, is distributed in the storage space by a yard scraper with a ¾-yd. bucket operated from a small building near the track. The second, or operating, floor in the building has enough windows to give the operator a clear view over the entire storage area. The yard will store 35,000 tons of coal. When reclaiming, the coal is

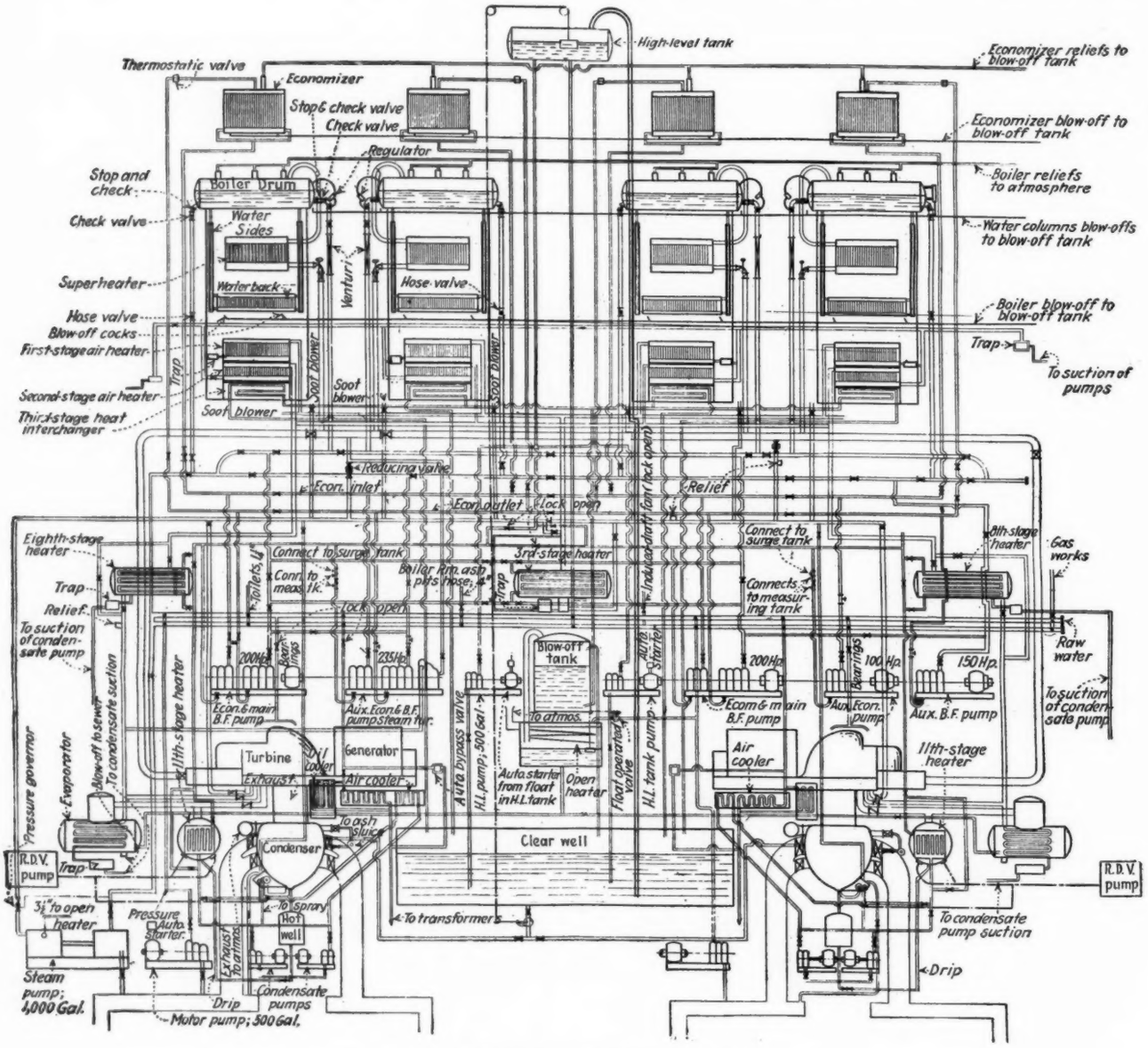


Fig. 4—Diagrammatic layout of plant

returned by the yard scraper to the concrete receiving pit to be handled by the system previously described.

A sluicing system was adopted for removing the ashes, as large areas on the property are to be filled, and it was decided that for several years to come this would be the most economical method of doing the work. The ash hoppers under the stokers are of 14-cu.yd. capacity. The space between the frames is filled with concrete applied with a cement gun and the entire surface of the ashpit lined with ground firebrick and cement. Steel bars and wire mesh reinforce the concrete and the lining. Provision for expansion and

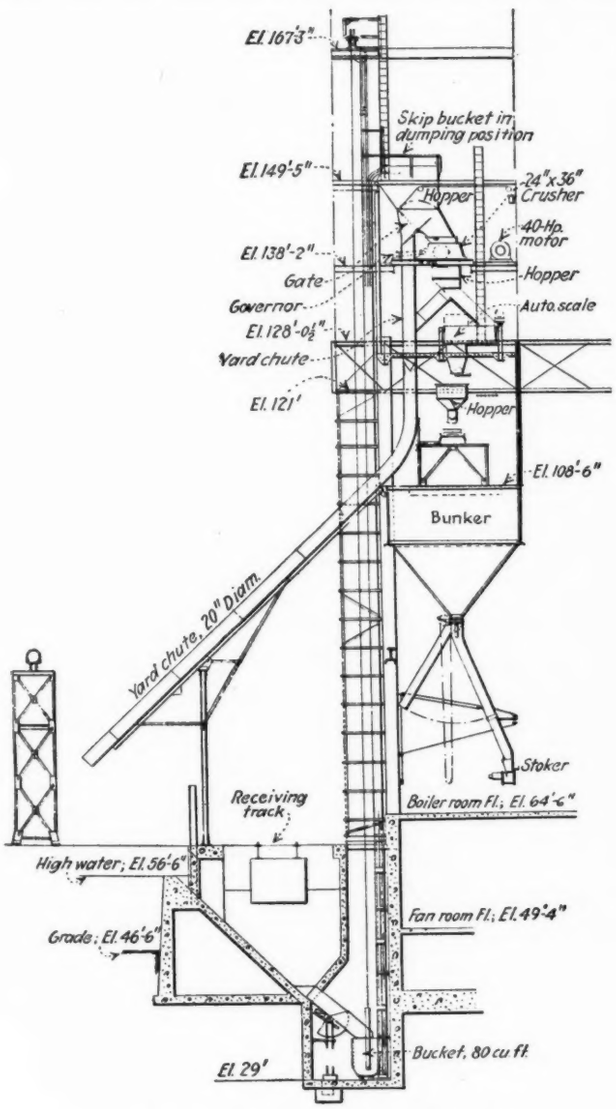


Fig. 5—Coal-handling equipment

contraction of the latter has been made by leaving ½-in. spaces at intervals along the side walls.

Cast-iron hinged doors form the bottom of the pit, and they are opened by means of a large handwheel on one side. The ashes drop down into a concrete flume 3 ft. wide and semicircular in cross-section arranged to be flooded with sufficient water for sluicing. Cooling water from the condensers is used, and the flow is to a sump room at one end of the plant. Here the ashes and water drop onto a grizzley, which holds back clinkers exceeding 4 in. in diameter. From the bottom of the well under the grizzley two manganese-lined dredging pumps take their suction and deliver to a wooden launder above, which distributes the mixture of ashes and water over the property forming the plant site. The driving motors are belt-connected and mounted higher up to be out of reach of the water. It is estimated that the ash-handling capacity of the system is about 25 tons per hour.

Steam Rates of Main Units

As previously stated, the main generating units are of 20,000 kw. capacity at 80 per cent power factor. The turbines are 14-stage Curtis machines, and their guaranteed performance is exceptionally good. With steam at 350 lb. gage and 239 deg. superheat at the throttle and a back pressure of 1 in. abs., in the exhaust chamber, the steam rates guaranteed per kilowatt-hour are: At one-half load, 10.3; three-quarter load, 9.7, and at full load, 9.95 lb. The condensers are of the single-pass surface type fitted with ¾-in. tubes and having outside grid coolers for devaporizing the air. The waterbox is divided so that one-half of the surface can be cleaned while the other half is in use. The actual surface installed is only 14,250 sq.ft., which is a provision of about 0.7 sq.ft. per kilowatt of generator rating, exclusive of the cast-iron cooler section. Owing to the large amount of steam bled for preheating, this amount of surface was considered ample.

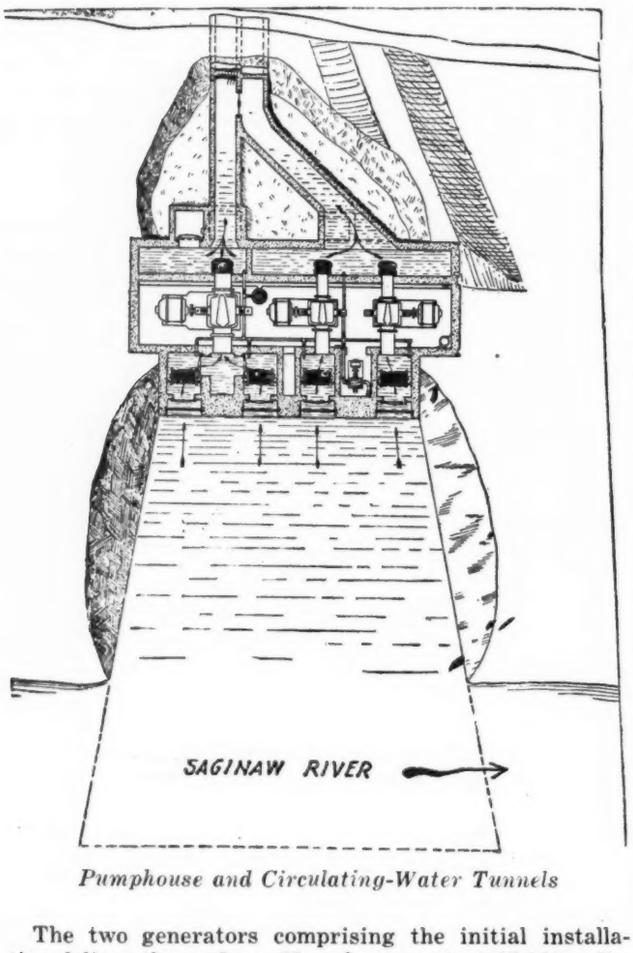
The condenser auxiliaries are motor-driven with the exception of the air jets, of which there are four primary and three secondary per condenser. The condensate pumps are in duplicate. For circulating the cooling water, unit No. 1 uses a 36-in. centrifugal pump driven by a 200-hp. motor. The second unit, however, is provided with two pumps, each of 24 in. diameter and driven by a 100-hp. motor, this division being made with a view toward more economical pumping as the supply varies with the temperature. These pumps are in a concrete intake house at the river bank some 800 ft. from the power house, which has been built large enough to accommodate the traveling screens.

Screenhouse Details

This building is a reinforced-concrete structure with a flat slab roof, and is waterproofed to the top, which is just above the maximum expected river level, and surmounted by a 15-ton gantry crane for removing equipment from the screenhouse and raising the sluice gates controlling the flow of water. The plan dimensions are 32x62 ft. over all and the depth 26 ft. Hooded air stacks provide for ventilation, an automatic sump pump takes care of the drips, and a 4-in. motor-driven pump is provided for unwatering any screen or pressure chamber and, if necessary, assist the sump pump in draining the main floor.

Two concrete tunnels, each 4 ft. square, carry the water to the condensers in the power plant, and the discharge tunnel alongside carries it back toward the river, an outlet being provided some distance from the intake house. As a safeguard a duplicate system of feeders supplies the pump motors. These lines are carried in ducts placed in the top slab of the concrete intake tunnels. Compressed air also is conducted to the intake house for blowing out the motors. The control of the pumps is entirely from the station switchboard, as normally it is not the intention to keep an

operator in the screenhouse. At times, however, some attention will be required, and telephone communication has been made.



Pumphouse and Circulating-Water Tunnels

The two generators comprising the initial installation deliver three-phase 60-cycle current at 12,000 volts. The main station bus and circuit breakers are arranged in duplicate. The bus is connected to the 12,000-volt generators through 2 to 1 auto-transformers. The entire 22,000-volt switching and transformer equipment, as well as the 140,000-volt apparatus, is outside the station building. This includes the station service and generator auto-transformers, the only electrical equipment inside the station being the main units themselves, the low-voltage station service switchboard and circuit breakers, and the plant auxiliaries. The entire substation, however, is operated from the main-station switchboard on the third floor in the south end of the building.

Generators, auto-transformers and connecting underground cables are protected from internal troubles by differential current relays which automatically trip the main oil circuit breaker, open the generator field and close the turbine throttle. The generators are cooled by a totally inclosed recirculating air system. Normally, condensate will be the cooling medium, but auxiliary sections of the cooler may be fed from the general cold-water supply system. The same water is used later for transformer cooling. No particular means for extinguishing generator fires is provided since it is felt that on account of the relatively small amount of air in the cooling system, the volume of oxygen contained is too small to allow combustion for any length of time. An alarm operated by thermostats in the air path is provided to give instantaneous warning of dangerously high air temperatures.

No Reserve Excitation Provided

Excitation for the generators, as has been the custom of the company for some time, is obtained from direct-connected units, there being no general exciter bus or reserve excitation provided. Each main exciter is rated at 110 kw., 250 volts, and is provided with a 125-volt shunt field winding which is separately excited from a 2-kw. machine directly connected on the end of the shaft of the main exciter. Voltage and load control is obtained by first cutting resistance into the field of the 2-kw. machine until a certain amount of resistance is in the circuit, when further operation

DATA ON PRINCIPAL EQUIPMENT IN SAGINAW RIVER STEAM PLANT

GENERAL

Location of plant	Zilwaukee, Mich. (near Saginaw)
Character of service	Light and power
Capacity, present, kva.	50,000
Ultimate, kva.	125,000
Boiler room, ft.	49x132
Turbine room, ft.	47x132
Offices, switchboard room, cable room, operators' floor and auditorium	4 floors, each 32x96 ft.
Width of firing aisle, ft.	16
Contractors	Building—O. W. Jenkins Co., Saginaw, Mich. Turbine—General Electric Co. Other equipment—Benjamin-Doublas Co., Ann Arbor, Mich. Electrical work—Construction Dept., Consumers Power Co.

BOILERS AND SUPERHEATER

Boiler manufacturer	Babcock & Wilcox Co.
Type of boiler	Wrought-steel, sectional cross-drum water-tube
Number installed	4
Steam-making surface per boiler, sq.ft.	9,283
Ratio steam-making surface to projected grate area	29 to 1
Furnace volume, cu.ft.	5,400
Steam-making surface, sq.ft. per cu.ft. of furnace volume	1.72
Furnace volume, cu.ft. per sq.ft. of projected grate area	16.7
Boiler pressure, lb. gage	375
Type of superheater	Foster radiant heat type
Manufacturer	Power Specialty Co.
Location of superheater	Uptake end below boiler tubes
Superheating surface per boiler, sq.ft.	242
Ratio superheating to steam-making surface	1 to 38
Steam temperature at 200 per cent rating, deg. F.	702
Corresponding superheat, deg. F.	260
Boiler meters and draft gages	Bailey Meter Co.
Valve-in-head soot blowers on boilers and economizers	Diamond Power Specialty Corp.
Water-back location	62 sq.ft. below superheater, 181.5 sq.ft. each side
Total effective water-back heating surface, sq.ft.	425

FUEL

Kind	West Virginia bituminous
Heat value B.t.u. per lb.	14,000

STOKERS

Manufacturer	American Engineering Co.
Type	Taylor underfeed stoker
Number per boiler	1
Width, ft.-in.	20-10½
Projected grate area, sq.ft.	324.3
Retorts per stoker	12
Pounds of coal burned per sq.ft. of grate area at 200 per cent rating	15.9

Efficiencies at different boiler ratings:

Per cent rating	100	150	200	300
Combined boiler econ. and furnace eff.	75	81	83	82

BOILER CONTROL SYSTEM

Forced-draft fans, manufacturer	Green Fuel Economizer Co.
Number of fans per boiler	1
Capacity per fan, cu.ft. per min. at 6 in. stat. press.	60,000
Fan motors, variable speed, General Electric	2 per fan
Induced-draft fans, manufacturer	Green Fuel Economizer Co.
Number of fans	1 per boiler
Size of fan	No. 7
Motors, variable speed, General Electric	2 per fan

Performance:

Rating	150	300	450
Lb. gas per hr. +10%	86,200	176,000	275,000
Temperature, deg. F.	290	350	425
Cu.ft. per min.	26,000	57,500	98,000
Pressure, in.	0.8	1.95	3.8
R.p.m.	170	306	482
Horsepower	6	32	123

Feed-water regulators (Copes)	Northern Equipment Co.

DATA ON PRINCIPAL EQUIPMENT IN SAGINAW RIVER STEAM PLANT (Continued)

ECONOMIZER

Manufacturer	Green Fuel Economizer Co.		
Heating surface, sq.ft.	8,500		
Performance:			
Rating boiler	150	300	450
Water, lb. per hr.	40,600	81,200	122,000
Gas, lb. per hr.	78,400	160,000	250,000
Temp. gas, deg. F.	525	665	800
Feed-water temp., deg. F.	200	200	200
Rise, deg. F.	93	126	156
Final gas temp., deg. F.	290	350	425
Approx. draft loss, in.	0.35	0.72	1.25

STACKS

Manufacturer	Wickes Boiler Co.
Number	One per boiler
Type	Self-supporting steel, unlined
Height above firing aisle, ft.	96

ECONOMIZER AND BOILER-FEED PUMPS

Manufacturer	Ingersoll-Rand Co.
Number of pumps	4 for 4 boilers
Two units, 2 pumps each, one 3-stage and one 4-stage, 500 g.p.m., 200-hp. G. E. motor	
One unit, 2 pumps, one 2-stage and one 3-stage, 500 g.p.m., 235 hp. G. E. turbine	
One unit, 2 pumps, one 3-stage and one 5-stage, 400 g.p.m., 100 hp. G. E. motor and 150 hp. Westinghouse motor	

EVAPORATORS

Manufacturer	The Griscom-Russell Co.
Number	2 for 4 boilers
Type	No. 80 Riley horizontal, submerged
Capacity each	7,600 lb. at 80 deg. F., temperature difference

HEATERS

One open heater		Cochrane Corp.
Closed heaters:		
Capacity, Lb. per Hr.	Source of Steam	Manufacturer
250,000	11th stage	Griscom-Russell Co.
250,000	8th stage	Griscom-Russell Co.
250,000	3rd stage	Ross Heater & Mfg. Co.

COAL HANDLING

Type	Drag line, skip hoist, screw feed, Schuttle-belt conveyor
Furnished by	Phillips, Lang & Co.
Capacity, tons per hr.	60
Crusher, one	Pennsylvania Crusher Co.
Overhead bunker, 188 tons per boiler, steel, lined with 1½-in. Gunite	
Coal distributed to bunkers by	Schuttle belt conveyor
Capacity, tons per hour	60
Yard coal storage tons	35,000
Method of reclaiming from storage, scraper conveyor, Sauerman Bros.	
Coal (West Virginia)	Hutchinson Coal Co., Cleveland

ASH HANDLING

Ashes are sluiced to sump from which pumped by two 8-in. Morris dredging pumps	
Ash hoppers over sluice trough, 14 cu.yd.	Phillips, Lang & Co.
Gates per hopper	Fourteen–18 x 36 in.

MAIN GENERATING UNITS

Manufacturer	General Electric Co.
Type of turbines	Curtis
Capacity each, kw. at 80 per cent p.f.	20,000
Number of units	2
Speed, r.p.m.	1,800
Throttle pressure and superheat	350 lb. gage and 239 deg. F.
Type of generator	3-phase, 60-cycle, 12,000 volt
Ventilation	Closed system with G. E. air coolers
Guaranteed performance of turbines:	
Steam pressure at throttle, 350 lb. gage; superheat, 239 deg. F.; back pressure in exhaust chamber, 1 in.	

Kw. Output of Generator	Lb. Steam per Kw.-Hr.
10,000	10.3
15,000	9.70
20,000	9.95

SURFACE CONDENSERS

Manufacturer	Ingersoll-Rand Co.
Number	2
Tube surface, each, sq.ft.	14,250
Sq.ft. of tube surface per kw. of generator rating	0.7
Connection to turbine	Rigid
Support	Springs
Condenser tubes	Muntz Metal
Circulating pump No. 1 unit, 36 in., gal. per min.	32,500
Drive	200-hp. G. E. motor
Circulating pump No. 2 unit, two 24-in., gal. per min.	16,250
Drive	100-hp. G. E. motor
Air jets per condenser	4 primary and 3 secondary
Condensate pumps per condenser	two, drive 30-hp. G. E. motors
Screens, traveling, four 5 ft. wide, submerged 10 ft., travel 10 ft. per min.	Chain Belt Co.

MISCELLANEOUS EQUIPMENT AND MATERIALS

Building steel	Bethlehem Steel Co.
Brick	Briggs Co.
Steel sash	Detroit Steel Product
Gratings for walkways	Adolph Johnson & Co. and Irving Iron Works
Firebrick	A. P. Green Fire Brick Co., Harbinson-Walker Refractories Co. and Armstrong Insulating Co.
Station crane	Whiting Corporation
Air compressor	Ingersoll-Rand Co.
Steam, water and air valves	Crane Co., Edward Valve Co., Schutte-Koerting Co., Yarnall-Waring Co., Lunkenheimer Co., Pittsburg Valve Fdry. & Construction Co., and Ross Co.
Piping and fittings	Crane Co.
Expansion joints	Crane Co.
Recording and indicating gages and thermometers	Bailey Meter Co., General Electric Co., Brown Instrument Co., Manning, Maxwell & Moore, Inc.
Silent chains	Link Belt Co.
Breeching and air ducts	Wickes Boiler Co.
Pipe covering	Keasbey Mattison Co.
Surge and storage tanks	Wickes Boiler Co.
Heating equipment	Consumers Power Co.

ELECTRICAL EQUIPMENT

Main oil circuit breakers—50,000 volts 1200/1600 amperes, outdoor type	General Electric Co.
Auxiliary station service circuit breakers	General Electric Co.
Auto transformers—3 phase, 12,000-24,000 volts	General Electric Co.
Main step-up transformers—3 single phase, 15,000 kva., 140,000-25,000 volts	General Electric Co.
Station service transformers—500 kva. single-phase	Allis-Chalmers Mfg. Co.
Disconnecting switches—22 kv. service, outdoor type	Electrical Engineers Equip. Co.
Main current transformers—22 kv. service:	
Up to 800 amperes	General Electric Co.
800 to 2,000 ampere capacity	Westinghouse Elec. & Mfg. Co.
Potential transformers, 22-kv. service	Westinghouse Elec. & Mfg. Co.
Lightning arresters, 22-kv. and 140-kv.	General Electric Co.
140-kv. oil circuit breakers	General Electric Co.
140-kv. motor-operated disconnecting switches	Railway & Industrial Engr. Co.
Station service switchboard	Westinghouse Elec. & Mfg. Co.
Permanent main switchboard	Not installed
Substation bus supports, 22 kv. and 140 kv.	Ohio Brass Co.

of the control switch automatically cuts resistance into the field of the main exciter.

The neutral of each generator is permanently dead grounded to protect the machine windings from the line potential to which they might otherwise be subjected on account of the auto-transformer connection.

Although this station is figured for an eventual generating capacity of 125,000 kva., no provision is being made for bus or feeder reactors. The low-tension oil circuit breakers have a rated interrupting capacity of approximately 1,000,000 kva. at 24,000 volts and are so designed that this rating may be increased at some later date to 1,500,000 kva. should this be desirable.

Each pair of generators and accompanying auxiliaries will be served by a bank of three single-phase 500-kva. station service transformers connected to the main station bus. No house generator or other source of station service energy is contemplated.

All equipment for use in the main 22,000-volt outdoor substation is built to standard 50,000-volt specifications. Each 140,000-volt feeder and the 140,000-volt side of each transformer bank is equipped with one circuit breaker and a pair of motor-operated air break switches. These switches are all controlled from the station switchboard, and by means of the air break switches any 140,000-volt circuit can be switched from one bus to the other at will by the switchboard operator. These switches are interlocked with the bus tie breaker as well as the line breaker to prevent faulty operation.

All engineering on this station, as well as on all other Consumers Power Co. stations, is being handled by the engineering department of the Commonwealth Power Corporation at Jackson, while the actual construction work is being done by contractors and by the construction department of the Consumers Power Co. The late J. B. Foote was chief engineer during the design and construction of this plant, with H. F. Eddy mechanical engineer and J. H. Foote electrical engineer.

Abnormal Current Transformer Secondary Voltages

By Ralph Brown

Under normal conditions of operation the voltage induced in the secondary of a current or series transformer is just enough to cause a current to flow through an ammeter, or wattmeter current coil, that is nearly directly proportional to that flowing in the primary. The standard full-load value of the secondary current is 5 amperes, and the number of primary and secondary

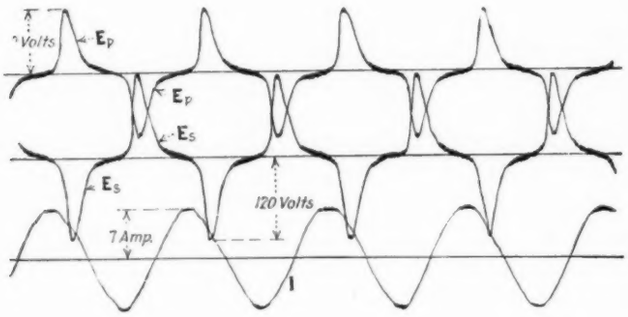


Fig. 1—Oscillograms of voltage and current obtained from current transformer with open-circuited secondary and 7 crest amperes in the primary

ampere-turns are nearly equal, the former being the greater. When the ratio of the secondary current to the primary current is normal, as is the case when the secondary load is one of low impedance, the magnetizing effect of the primary ampere-turns is almost completely neutralized by the demagnetizing effect of the secondary ampere-turns, since the primary and secondary currents, being 180 deg. out of phase, directly oppose each other.

Core Normally Magnetized at Low Density

To obtain desirable phase angle and ratio characteristics, the core loss must be small, hence the iron composing the core in a current transformer is normally magnetized at low densities, and the potential induced in the secondary winding is rarely greater than 20 volts.

With no flow of current in the secondary winding no opposition is offered to the magnetizing effect of the primary ampere-turns, and for any value of primary current the core flux will be greatly increased over that existing when the secondary circuit is closed. Since the number of secondary turns remains unchanged, an increase in magnetic flux must result in an increase in the secondary voltage.

Even with a small primary current flowing, an indication of potential will be obtained by connecting a 150-volt voltmeter to the secondary terminals, and after the core becomes saturated, which will occur at much less than full-load current, the secondary voltage will increase in proportion to the primary current. If the wave form of the secondary voltage was a sine curve, its crest value would be 1.41 times the effective value, as indicated on any ordinary voltmeter. Owing to the cyclic variation in the reluctance of the core, especially at high densities, the magnetic flux cannot follow a sine wave. The result is that the secondary voltage is so badly distorted by the presence of harmonics, the most prominent of which is the third, that the crest voltage can be obtained only by special means, such as by use of a kenotron tube or an oscillograph.

Under the direction of Reed P. Crippen at the University of California, tests were recently made to visualize the wave form of the secondary voltage of a 60- to 5-ampere current transformer having 14 turns on the primary and 164 turns on the secondary. Fig. 1 is a reproduction of conditions existing with a primary current of 5 effective amperes, or 7 crest amperes, flowing. The lower wave *I*, indicates that the primary current is practically a sine curve, while the center curve E_s, shows that the secondary voltage is badly distorted, even though the primary current is but 8.3 per cent of normal. The crest value of the secondary voltage is 120 crest volts, and the corresponding value for the primary voltage E_p is 10 volts, E_p being the drop across the primary winding, which, with the secondary open, acts like a choke coil.

The current curve *I*, Fig. 2, is slightly distorted from a true sine wave, while the wave form of the primary voltage E_p bears no resemblance to a sine curve. The secondary voltage curve E_s is even more distorted, and its crest value is 500 volts. The ratios of the crest values of the primary and secondary voltages, as shown on both oscillograms, are nearly equal to the turn ratio of the windings, which is 11.7 to 1.

Induced Voltage in Transformer Secondary

Considering the foregoing, it is doubtful if the crest value of the distorted voltage that is induced in the open secondary winding of any standard current transformer at full-load primary current will exceed 2,000 volts, even when the transformer ratio is 500 to 1. However, the open-circuit potential of any current transformer, except for very small values of primary current, is undoubtedly hazardous, even though an ordinary voltmeter might not indicate the existence of a dangerous voltage. Oscillograms indicate that the crest voltage does not attain a high instantaneous value at the moment that the secondary circuit is opened, therefore failure of a current transformer that is operated on open-circuit appears to be due to the abnormal stress on the insulating material occasioned by the sustained high crest voltage and the effect of the high temperature produced by the greatly increased iron losses.

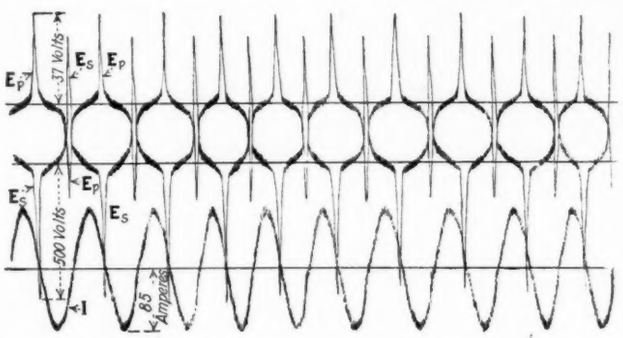
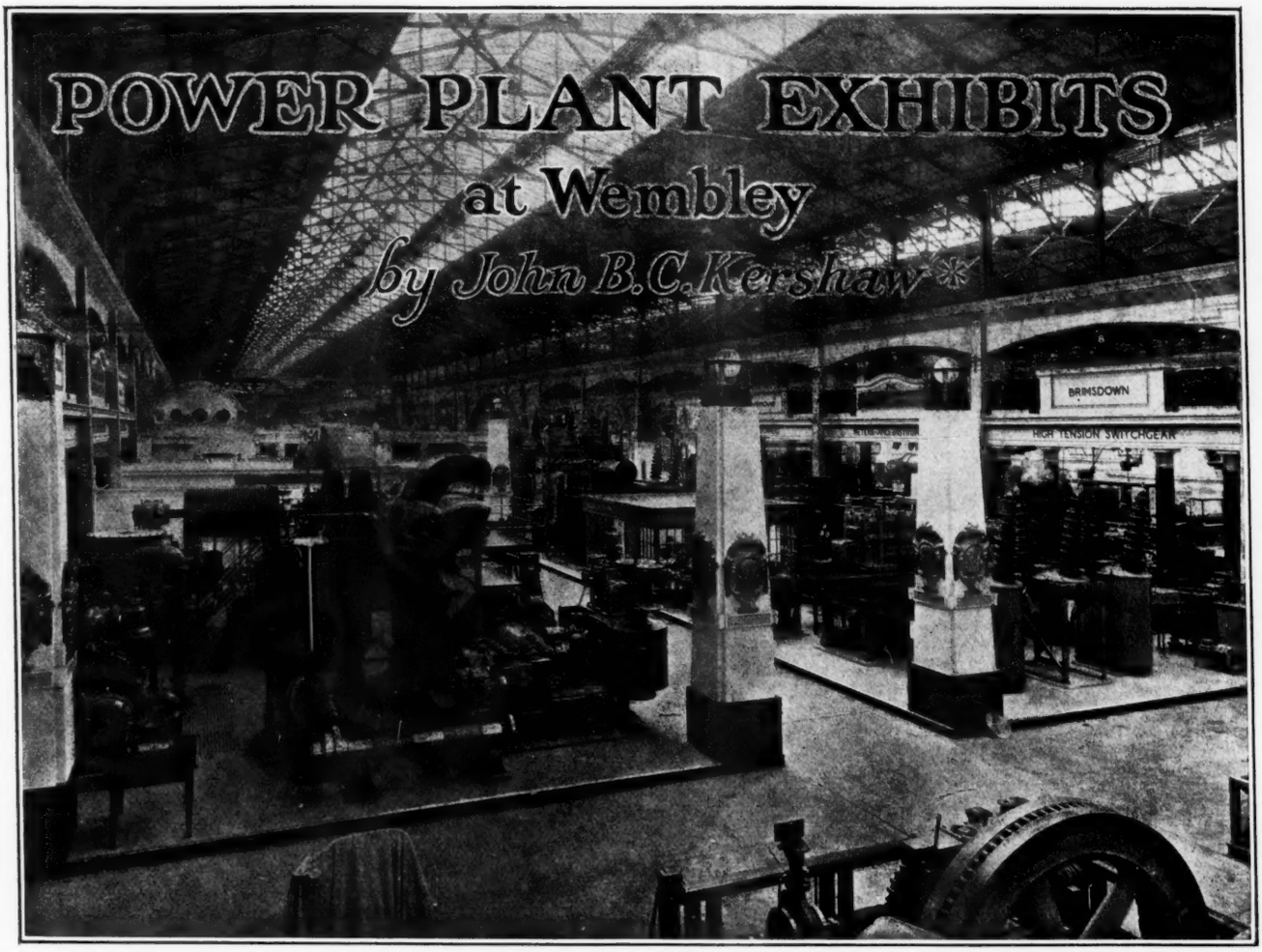


Fig. 2—Oscillograms of voltage and current obtained from current transformer with open-circuited secondary and 85 crest amperes in the primary

POWER PLANT EXHIBITS at Wembley

by John B. C. Kershaw*



IN THE Engineering building of the British Empire Exposition, visitors after covering boiler-room equipment described in *Power*, July 15, will note the display of steam turbines, shown in most cases with electrical generators. In several instances parts of the turbine casings have been removed, while sections of the turbines are separately exhibited in order that the operation of the machines may be understood.

The General Electric Co., Ltd., for example, on their stand show many appliances for the generation, transmission and application of electricity, including a Fraser & Chalmers 5,000-kw. three-phase turbo-alternator, which, although not actually under load, is revolved slowly by a motor. The machine is designed to run at 3,000 r.p.m. and has eleven wheels, each with a single row of blades. So that live steam shall not come into contact with the main casing, the turbine has cast-steel nozzle boxes, and the high-pressure end of the casing itself is of cast steel, the labyrinth packings being of steel in order to avoid distortion; for accessibility the top half of the casing can be dismantled without interfering with the steam piping or governing unit. The exhibit also includes a turbine wheel completely bladed.

Still another exhibit of special interest is that shown by C. A. Parsons & Co. of a 12,000-kw. turbo-generator (Fig. 1) built for the South African Railway administration. This turbine operates at 3,000 r.p.m., 250 lb. pressure and 700 deg. total steam temperature, the vacuum being 28½ in. Four-stage bleeding for feed-water heating is provided. At its most economical load, 12,000 kw., the water rate is 10.3 lb. per kw.-hr. Being intended for railway service, where high peak loads occur, the maximum capacity was set at 20,000 kw. Each rotor is a solid steel forging bored end to end in order to guard against pipes or flaws in the center. It will be seen from the illustration that large gaps or recesses are machined in the low-pressure rotor both for the purpose of reducing the weight and to permit examination of the forging for soundness of the metal.

Four surface heaters are supplied, the first one raising the condensates from 88 up to 93 deg. F. by means of heat recovered from the drain water of the succeeding heaters. Steam is bled from the low-pressure cylinder for the next stage, which increases the temperature to 135 deg. The third heater receives steam from the secondary nozzles of the air ejectors, raising the temperature to 145 deg. and the fourth, which receives steam exhausted from the high-pressure cylinder, heats the water up to 180 deg. From here the condensate goes to the boiler-feed pumps and then through the fifth surface heater, which receives the steam-pump exhaust and raises the temperature to 210 degrees.

This company also shows a model of the 50,000-kw. unit that is to be installed by Commonwealth Edison at Chicago. The scheme is that of a high-pressure and intermediate-pressure and a low-pressure set, all on different shafts. The high-pressure set, which takes steam at 500 to 550 lb. and 700 deg. F. total temperature, has a nominal output of 23,300 hp. at 1,800 r.p.m. and is

*British correspondent.

direct coupled to a 16,000-kw. alternator. The steam is expanded to about 70 to 80 lb. and is then reheated or alternatively passed direct to the intermediate-pressure set. This latter set does the bulk of the output, it being rated at 40,300 hp., which corresponds roughly to 29,000 kw. at the alternator terminals, although this end is actually labeled 40,000 kva.

The third, or low-pressure set, is constructed coaxially with the second, a single pedestal carrying the end of one shaft running at 1,800 r.p.m. and the end of another running at 720 r.p.m. This pedestal is inside a hollow cone which carries the steam from the intermediate cylinder to the low-pressure cylinder. The last set has an alternator that is labeled 8,000 kva., so that the turbine gives approximately 8,900 horsepower.

For the layman the model of a cotton mill driven by belted turbines is of extreme interest. In striking contrast to American practice, the drive is entirely by ropes, the turbine being connected to the driving pulley by a reduction gear. Likewise a small ½-kw. turbo-generator running at 9,000 r.p.m. brooks comment, since it is some 30 years old and is identical in design with the original Parsons machine constructed in 1884.

The Brush-Ljungstrom turbine, on the stand of the Brush Electrical Engineering Co., Ltd., is of the double-rotation reaction type. It has two rotors turning in opposite directions; each rotor is coupled to an alternator, the alternators being connected electrically. They are bolted to the turbine casing and the whole turbo-generator is mounted on the condenser, so that no heavy bedplate is needed, the light weight and symmetrical arrangement permitting this. The blade system of a 5,000- to 7,000-kw. turbine on exhibition is shown in Fig. 2.

While of most interest to railroad circles power-plant engineers will be interested in the geared-turbine locomotive exhibited by the North British Locomotive Co. The machine was built under the Reid-MacLeod patents and is fitted with two-stage turbines, operating condensing.

Steam turbines are also represented by three 1,500-kw. units—one built by the English Electric Co. a second by James Howden & Co. and a third by the British Thomson-Houston Co., and installed in the power house. A view of the turbine room appeared in *Power*, May 27.

Davey, Paxman & Co. show a 400-kw. tandem-compound poppet-valve engine direct-connected to a generator. A 115-hp. unaflow is exhibited by James Carmichael & Co. The unusual feature of the machine is the two-piece piston, the connection of two heads which are screwed together in their position on the rod being fixed by a collar turned on the shaft.

Of the condensers on display the contraflow units exhibited by Vickers, Ltd., and by Richardson, Westgarth & Co., licensees of the Contraflo Engineering Co., attract much attention, Fig. 4 being a cross-section view of a 40,000-sq.ft. unit. The steam inlet is arranged so that it extends fully two-thirds around the condenser, thus providing an initial surface of exceptionally large dimensions to meet the incoming steam. At the point where the proportion of air present becomes more pronounced, the cooling surface of the condenser is divided into two or more parallel compartments, according to the requirements. These subdivisions are made by plates arranged to lie in the line of the steam flow through the condenser and thus in no way to interfere with the passage of the steam or to cause any resistance. The effect of these divisions is that the air and other non-condensable gases are gradually concentrated toward the narrow outlet, with the result that the air at that point is of greater weight per unit of volume than at any other part of the condenser and is consequently in the most desirable condition for withdrawal by the air pump. In the devaporizing chamber the quantity of vapor still in association with the air is further reduced by condensation and the air is cooled down to a low temperature before extraction by the air pump.

The effect of localizing the air region is, that a very high transmission rate of heat through the walls of the tubes to the circulating water is maintained, with the natural consequence that the highest possible vacuum is obtained with a given quantity of circulating water and a given tube surface.

In the power plant one of the turbines is fitted with a

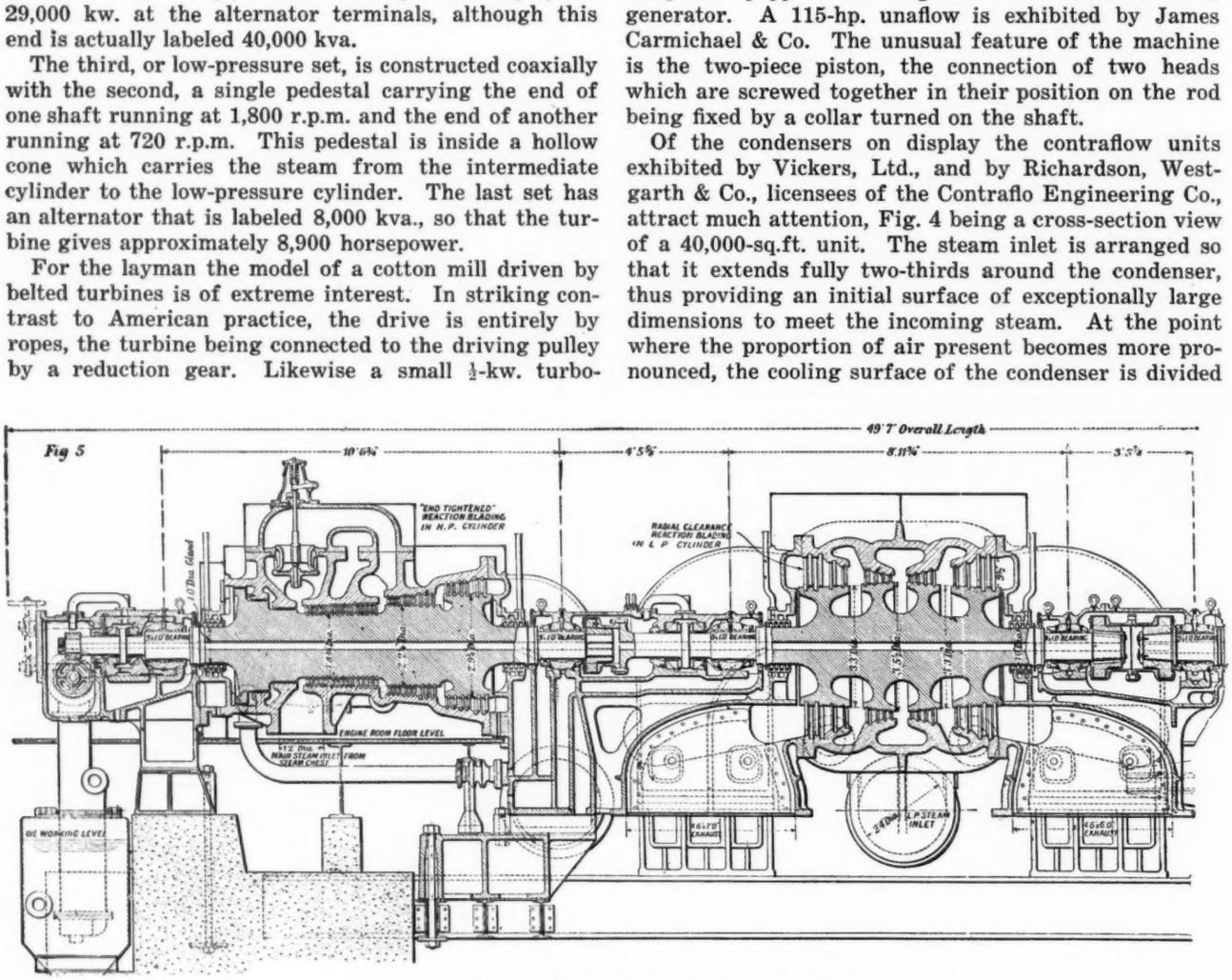


Fig. 1—12,000-kw. Parsons tandem turbine

surface condenser and auxiliaries built by John Musgrave & Sons, the second turbine has a Cole, Marchent & Morley condenser, while the third turbine is served by a Hick, Hargreaves & Co. condenser.

Mirrlees-Watson display a jet condenser complete with rotary air and water pump. They also show a steam-jet air ejector; this is a two-stage unit with two steam-condensing compartments and is installed on the turbine locomotive heretofore mentioned as being on display.

The Allen Compactum Air Ejector is an improved form of steam-jet air pump, suitable for the removal of the air and vapor from condensers. The casing of the ejector contains tubes through which the condensate is discharged by the condensate pumps, and the operating steam from the primary and secondary nozzles of the apparatus is condensed on the outer surface of these tubes. All the heat remaining in the operating steam, after it has compressed the air and vapor extracted from the condenser, is therefore transferred immediately to the condensate. The apparatus acts as an air ejector and secondary steam jets and the corresponding compartments. The primary steam jet withdraws air and vapor from the main condenser and discharges the mixture, together with the operating steam, into the feed-water heater combined. The secondary ejector withdraws the aërated vapor from the first condensing compartment and discharges it with its operating steam into the second condensing compartment, which is usually at about atmospheric pressure. The condensation in both compartments takes place on the tubes through which the main condensate is delivered. The drainage water from the compartments may be discharged into the main condenser through a suitable balance pipe or in any other conveninent manner.

Another interesting air ejector is the Hick-Breguet,

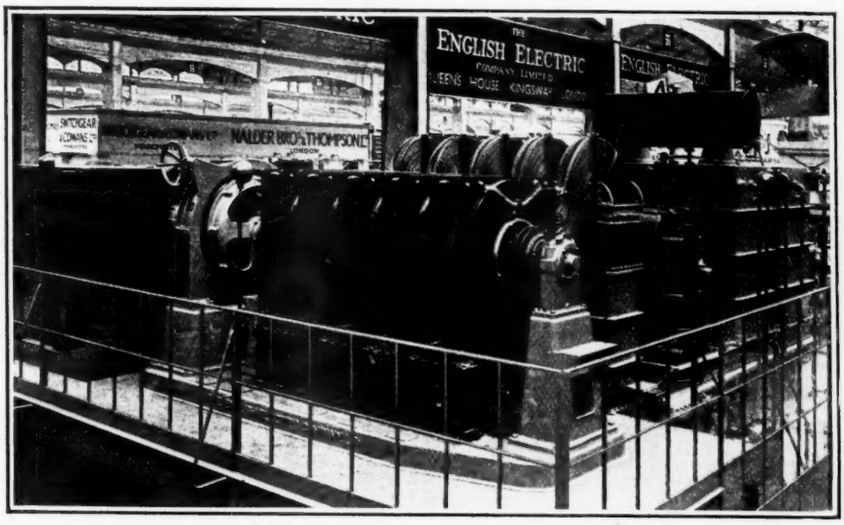


Fig. 3—Transverter makes possible direct current of 100,000 volts

Fig. 6. This consists of two steam jets with an intermediate condensing chamber, which arrangement constitutes a two-stage effect.

The increasing tendency with modern plants to make the feed-water circuit a closed one and to use only the condensate from the condensers for feed purposes, renders it more and more important to remove all traces of oil from the latter, before it re-enters the boilers.

James Gordon & Co. exhibit the Massip Oil Separator, for extracting the oil that would otherwise be carried over by the exhaust steam from the engine into the condenser. The principle of this separator is to pass the steam through a series of curved plates against which the particles of oil are carried by centrifugal force. The spacing of these baffle plates is calculated in such a manner that the velocity of the steam is considerably decreased during its passage through the sheaf of baffle plates. The oil adhering to these plates drains into the lower chamber of the separator, where it is prevented from coming into contact again with the steam.

The Vickcen Oil Separator, exhibited by British Separators, Ltd., is designed for the purification of fouled lubricating and fuel oils. For many years the centrifugal cream separator has been part of the standard equipment of every dairy, but it is only of late years that the possibility of applying the principles of milk separation to the purification of lubricating and insulating oils has been realized.

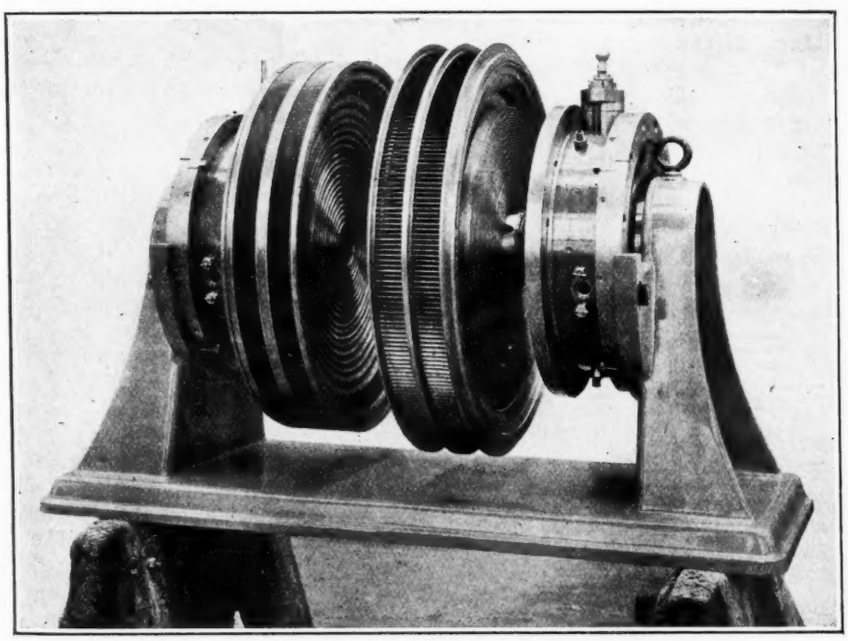


Fig. 2—Blade wheels of Brush-Ljungstrom

Most electrical engineers in Great Britain regard

the transverter, Fig. 3, on the stand of the English Electric Co., Ltd., as the outstanding electrical exhibit. Its main purpose is to permit the use of direct current for transmission purposes, while retaining the alternator as the generator. Being reversible, it will take alternating current of any kind and convert it into direct current at high voltage, while a similar machine

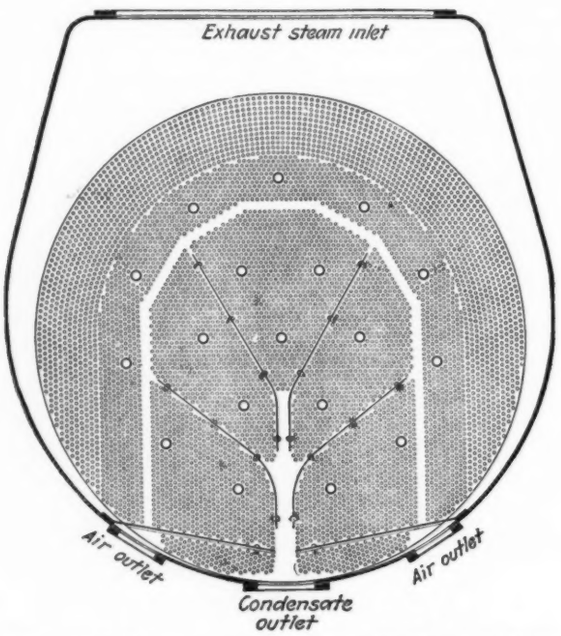


Fig. 4—Tube arrangement of contraflow condenser

at the receiving end will convert the direct current into an alternating current at any desired voltage. It can also be arranged to change direct current from one voltage to another. The machine exhibited, the first of its kind has a capacity of 2,000 kw., taking in energy at 6,600 volts three-phase fifty cycles, and delivering direct current at 100,000 volts. The machine is really

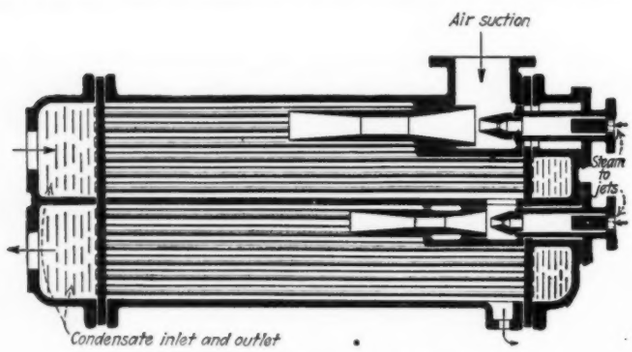


Fig. 5—Compactum air ejector

a combination of static transformers and rotary converters, the only moving details being the rotating brush arms, which are driven by a small motor.

Without going into the complete theory, it may be stated that the effect is similar to that in a direct-current generator, with electromotive forces produced and current flow similar to those in the direct-current armature. Consequently, by rotation of brushes on the stationary commutator, direct current of steady voltage can be obtained. The brush gear must be in synchronism with the rotating field, and for this purpose a synchronous motor of the self-starting type, with its own exciter, is employed. Its stator can be rocked backward and forward in order that the position of the brush gear, driven by the motor, may be varied as required with respect to the neutral point of the commutator. The transformer unit has a cast-iron bedplate on which the transformers are mounted. The leads to the commutator are taken out through vertical trunks, the whole being arranged as an oil tank.

The electrical exhibit was sponsored by the British Electrical and Allied Manufacturers Association, and completely covers the entire industry, ranging from household electrical devices to high-tension switching gears. Mention may be made of the exhibits of Ferguson Pailin & Co., of Manchester, as showing present

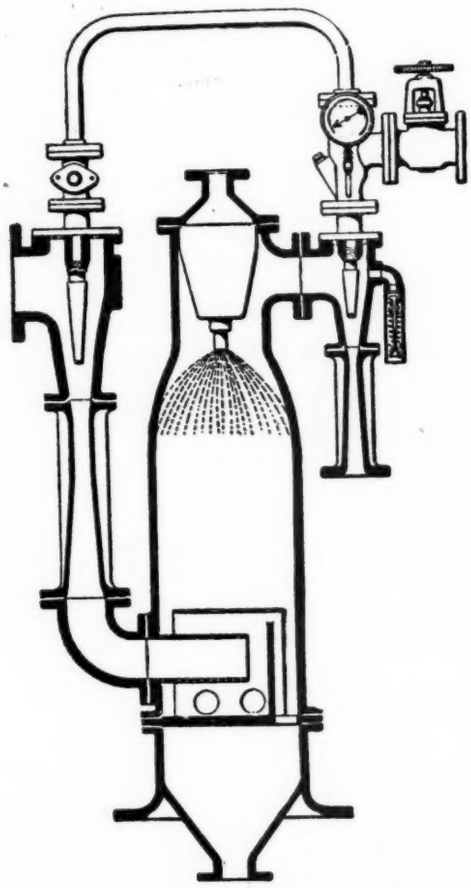


Fig. 6—Hick-Breguet air ejector

practices in high-tension apparatus. The firm exhibits various examples or armor-clad, compound-filled switch gear for currents ranging from 6,000 up to 135,000 volts. The circuit breaker is designed for outdoor service and is totally inclosed. It is made in single-pole units, but any number of units may be assembled together to form a multiple breaker. The compound-filled condenser terminals, being shrouded by porcelain petticoats, have adequate protection against rain and snow, while a plain porcelain shroud covers the lower portion of each terminal, providing protection against carbonization due to the arc. Electrostatic shields, which diminish the stress on the oil, inclose the self-aligning finger-pattern fixed contacts. A Bakelized contact bar carries the moving contacts, the latter being of inverted V cross-section.

(Concluded next week)

The Industrial Executive—His Power Plant and His Engineer

By Egbert Douglas*

In a recent conversation with the head executive of a large industrial concern I put this question: "Why is it that the industrial power plant is left to drift with the tide of time, and nothing is done to it until it refuses to function; and then what is done is in such a slipshod and hit-and-miss fashion?" This was the answer: "There are two groups of expenses about this establishment which are looked upon as nuisances; these are the office force and the power plant; neither is classified as a productive department, and therefore any outlay on them is not viewed with favor unless it is absolutely necessary to keep them functioning."

This is one of the most satisfactory explanations for the generally deplorable condition to be found in the average industrial power plant that has come to my attention, and in a substantial measure it explains why the power-plant engineer is looked upon generally as a "dub" in the industrial organization. It also shows rather conclusively wherein the operating men have failed in not getting their superiors into the frame of mind of looking at the power plant from a different viewpoint.

Little has been heard in recent years about power, except from sources connected with the sales organizations of power companies or from sales engineers connected with equipment manufacturers, who were in the business of selling largely to the power distributing companies. The industrial executives have come in contact with these people ten times while they have come in contact with their own engineers once, and often, when wanting information about their power-plant problems, they seek it through sources that are bound by business connections to give biased views.

Why the Engineer Is to Blame

Who is at fault? Is it the executives or the engineers in charge of the power plants, or both? I believe a large part of the fault lies with the engineers in not giving the executives the right point of view about their power plants and their effect on our general economic condition.

Most engineers know that power-producing engines or turbines are wasteful pieces of apparatus so far as heat utilization is concerned. The largest steam turbines in operation today in the best so-called superpower plants take less than 25 per cent of the heat from the steam that drives them. But when heat and power are considered together, highly efficient combinations are possible and such combinations can be found in relatively small plants.

Business executives do not realize these truths, and they do not consult their own engineers in an endeavor to find out about them. The result is we are wasting millions of tons of coal in our industrial establishments by failing to analyze properly our costs in the heating and power plant, which has been relegated to the nuisance division of our industrial structure.

The industrial executives of this country have heard and studied and listened to the economies of the central-station power plants with far more zeal than they have their own power plants, and yet the industrial power plants of this country burn four times as much coal as all the central stations consume.

The method of keeping books with respect to the industrial power plant displays an angle on this part of our industrial establishments that is rather illuminating. For example, I recently had occasion to look over some cost figures of the operations of an industrial power plant and found that all building maintenance was charged to the power-plant department, because the building maintenance men were reporting to the chief engineer of the power plant. If a window was broken in the president's office or a freight elevator in the factory needed new cables, this expense went against the power plant. Yet, if the power plant were completely abandoned, these expenses would go on just the same.

With such a system of accounts it is little wonder that the power plant has become the head of the luxury division and that the executive has become converted to the idea that his plant is a nuisance and a luxury. In such cases it behooves the engineers to keep some accounts of their own, and at the proper time they can easily change the classification of accounts in the general office so that a more logical cost statement of power and heat will appear.

It not infrequently happens that all the oil used throughout a large factory is charged to the power plant, because this department usually purchases or orders all oils. Intangible depreciation is also heavily loaded onto the power plant, not only that part which is directly in the power plant, but a liberal proportion of the depreciation of the entire factory. Depreciation is the subterfuge behind which many unknown figures are hidden, and the unoffending heating and power plant is usually the most convenient place to throw this intangible expense.

Engineers are not expert accountants nor do they need to be. They can, however, readily distinguish between productive items in the power plant and the ones that are not. Accounts are nothing more than correct recording of facts. So if the operating engineers will just view their power plants as if the business were their own, and anything they spend in them, or out of them, be carefully put down when and where it was spent, what it was for and how much it cost, and how much was for labor and how much for material, it will work wonders. With this kind of information at hand, we will not have to worry about heating and power costs and we may find in studying the figures on the plant's expenses, that the executives have been misleading themselves through erroneous bookkeeping with respect to power and heating costs.

There are opportunities for cutting the costs of heat and power in our industrial establishments, that would be little short of startling if all the facts pertaining to this department were generally known. A closer relationship between the engineers and the executives and a broader viewpoint that possibly economies can be uncovered that will work wonders in our power and heating problems.

In a speech recently made before the German "V.D.I.," its president, Dr. Klingenberg, used the term "*Parade-Wirkungsgrad*" to signify the efficiency obtained on test. Literally translated, this means "parade efficiency." With all due respect to tests, and parades as well, does not this little phrase hit the nail on the head?

*Cahill & Douglas, consulting engineers, Milwaukee, Wis.

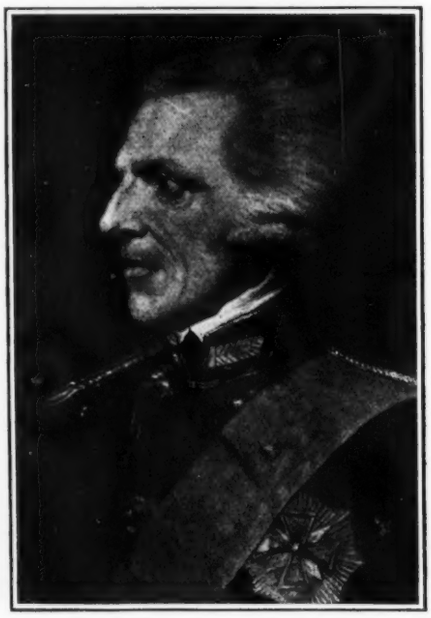
Lives of the Pioneers of a Great Science

By ENGR. CAPT. EDGAR C. SMITH, O.B.E., R.N.

In this article the writer endeavors to place before the reader a brief account of the lives and the work of the men who first discovered the scientific principles underlying all power engineering.

ONE of the great landmarks in the history of science, the establishment of the fundamental laws of thermodynamics, rivals in importance the enunciation of the theory of gravitation. A century and a half separate the two discoveries, and while Newton's work was done in the latter part of the Seventeenth Century, the founding of thermodynamics belongs to the first half of last century.

British men of science were specially concerned in much of the pioneering work on the subjects of heat and work, and when Queen Victoria celebrated her Jubilee in 1887, the well-known physicist, Tyndall, wrote "of the law of the conservation of energy which enables the eye of science to follow the flying shuttles of the universal power as it weaves what the earth spirit in Faust calls 'the living garment of God' as the largest flower in the garland which the science of the last fifty years has to offer to the Queen." On another occasion he referred to it as the greatest subject hitherto unfolded to the human mind. Embracing as it does the equivalence, the conservation and the dissipation of energy, the modern doctrine is one of the most fruitful studies of the engineer, and its early history is bound up with the first steps in the true understanding of all heat motors.



Benjamin Thompson (Count Rumford)

At a time when it is generally agreed that greater recognition should be given to the history of science and of engineering, it is perhaps not without interest to recall briefly the lives and achievements of the founders of this important branch of human knowledge.

With the ever widening realm of science of today the numbers of workers multiply so fast that it is impossible to know much of their personal history. Biography, however, is one of the most fascinating of studies, and it is therefore the aim of this article to show who were the pioneers of the science of thermodynamics and to give a few details of their lives.

When these pioneers began their work, the material theory of heat and the idea of caloric held universal sway while, thanks to their labors, within fifty years these errors had been abandoned and the engineer had been put into possession of the principles by which he has been enabled to increase the efficiency of his power plant threefold or fourfold.

The compound engine, the triple-expansion engine and the steam turbine may be said to be among the fruits of the work of Carnot, Joule, Rankine and Kelvin as is also the improvement of the internal-combustion engine.

In England no name is held in higher esteem among men of science and engineers than that of Joule and the centenary of his birth celebrated in 1918, led to the founding of a memorial lecture at Manchester where the greater part of his life was passed.

The first of these memorial lectures was delivered in 1920 by Sir Dugald Clerk, one of the most distinguished internal combustion engineers of England, while the second was delivered in 1922 by Sir Charles Parsons, the eminent inventor and the improver of the Parsons steam turbine. While the former took for his subject, "The Work and Discoveries of Joule," the title of the lecture of Sir Charles Parsons was "The Rise of Motive Power and the Work of Joule."

Benjamin Thompson, Count Rumford

Though the idea underlying the principle of the conservation of energy had been thought of before and though men had hazy notions that there was some subtle connection between heat and work, the first to show definitely that by the expenditure of mechanical work heat could be produced in inexhaustible quantities was Count Rumford who, as plain Benjamin Thompson, started life in the small colonial town of North Woburn in Massachusetts.

He was born there in 1753, the year his great countryman, Benjamin Franklin, received the gold medal of the Royal Society of London for inventing the lightning conductor.

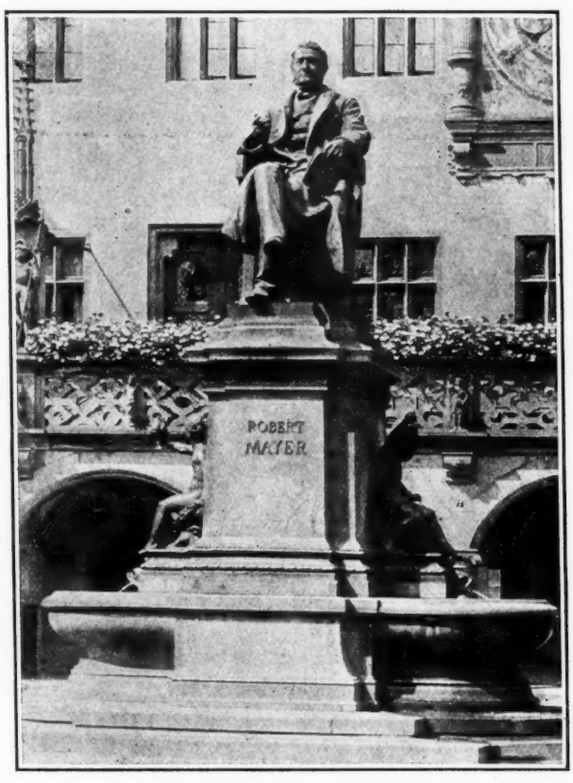
Apprenticed to a storekeeper, Rumford was enabled to study a while at Harvard and then became a schoolmaster, first at Wilmington and then at Rumford, a

town now known as Concord. Next made a major in a provincial regiment, Rumford began experimenting on guns and gunpowder. Regarded as lukewarm in the cause of liberty, he left America for England, was made an under secretary in the colonial office and recrossed the Atlantic as a lieutenant-colonel in George the Third's dragoons.

Once again in Europe, he took service under the Elector of Bavaria, and for the next ten or eleven years his headquarters were in Munich. He was made Sir Benjamin Thompson by King George, and in 1791 he became a count of the Holy Roman Empire taking his title from the place where he had taught and where he had married the squire's widow.

Rumford's duties at Munich were of a diverse character, and among them was the superintendence of the making of cannon in the arsenal. It was here that he made his remarkable observations on the heat produced by friction. In an experiment in which a steel borer was pressed against gun metal with a force of 10,000 lb. and revolved at 32 r.p.m. by the work of two horses, sufficient heat was generated in $2\frac{1}{2}$ hours to boil $18\frac{3}{4}$ lb. of water. The amount of heat generated he estimated as equal to that given out by nine wax candles each $\frac{3}{4}$ in. in diameter.

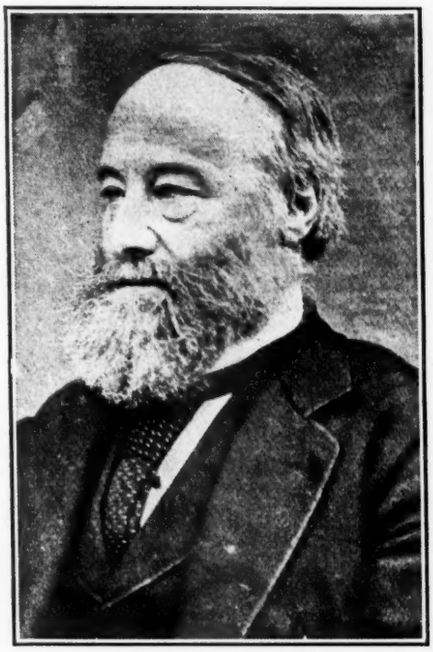
Rumford gave an account of his experiments to the Royal Society in 1798, but little notice was taken of



Julius Robert von Mayer

them. It was soon after this that Rumford took the initiative in the founding of the famous Royal Institution. The latter part of his life was spent in Paris, where he made a second and very unhappy marriage, this time with the widow of the chemist Lavoisier. He died and was buried at Auteuil, a suburb of Paris, in August, 1814.

The next contribution to the subject was made by the celebrated chemist Humphry Davy, who, by simply rubbing two pieces of ice together, was able to melt them by the friction set up. Like Rumford he was led to the conclusion that heat was not a material sub-



James Prescott Joule

stance, but a motion of the molecules of bodies. Neither of these distinguished investigators, however, pursued the matter any further.

Nicolas Leonard Sadi Carnot

We now come to the work of one whose name is indelibly written in the history of thermodynamics. This is Carnot, who published in 1824, one hundred years ago, his essay "Reflexions sur la Puissance Motrice du feu," which was called by Lord Kelvin, "an epoch-making gift to science." Carnot's great reputation rests on this single work.

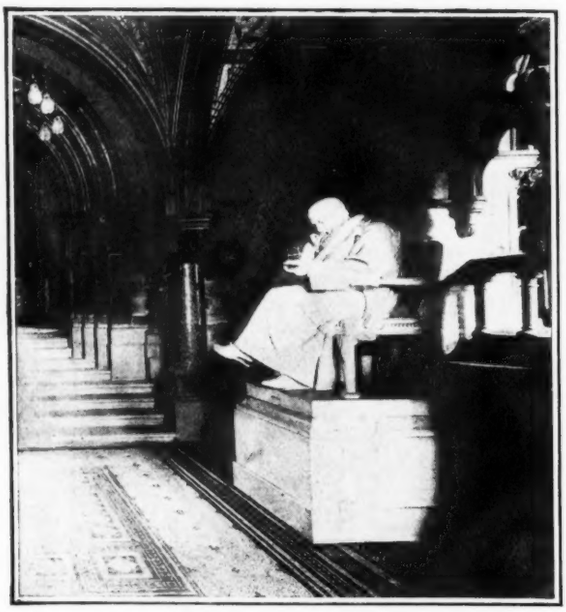
At the time it appeared, it is true, it had but a limited circulation and gained but little attention, yet after its author's death it was destined to provide the basis of the inquiries of many eminent men of science.

Nicolas Leonard Sadi Carnot was the son of the great Carnot who played such a notable part as an administrator during the Revolutionary period in France. Born June, 1796, in the Palace of the Luxumbourg, the ancient home of the French kings but then the seat of government, young Carnot was named Sadi after the old Persian poet and moralist whose writings his father admired.

He attended the Lycee Charlemagne and in 1812 became a student of the Ecole Polytechnique, an institution that numbered among its staff some of the most eminent mathematicians of the day. Here Carnot gained a high position and though too young to take a part in the campaigns of Napoleon, he passed into the corps of engineers and for some years was engaged in the ordinary duties of his profession in various garrison towns. Given a post in Paris in 1819, he was promoted

to a captain in 1826, the following year retired from the service and five years later, August 14, 1832, he fell a victim to the epidemic of cholera which swept across Paris, being then but thirty-six years of age.

With Carnot's death his essay nearly passed into oblivion, a fate it was saved from by the publication in 1834 of a paper "Sur la theorie mechanique de la



Statue of Joule in the corridor of City Hall, Manchester

chaleur" in the Journal of Ecole Polytechnique. This was from the pen of Paul Emile Clapeyron. In his paper Clapeyron commented on the ideas of Carnot, and it was his remarks that led the young student-physicist, afterward to become so well known as Lord Kelvin, to search for the essay of Carnot. Most text-books on heat and the steam engine give the explanation of Carnot's cycle of operations and his demonstration of the measure of efficiency, which it is not necessary to repeat here.

Though Carnot in his memoir adopted the material theory of heat, by his notebooks, extracts from which were published long after his death, it was found that he had come to the conclusion that heat was a kind of motion, and there can be no doubt that his early death not only robbed the world of an original and profound thinker, but also delayed for some years the development of the modern doctrine of heat. It is perhaps worth pointing out that Carnot's attention had been drawn to the subject by his inspection of the steam engines he saw in the course of a series of visits he paid to industrial establishments in Paris and elsewhere.

Clapeyron, who was born in 1799, was, like Carnot, a student of the Ecole Polytechnique, from which he passed into the public works service of Russia. Returning to France in 1830, he became one of the pioneers of French railway engineering and built many bridges and locomotives. He died in January, 1864, being at the time a member of the Paris Academy of Sciences.

Another French engineer who ought to be mentioned in this connection was Marc Seguin (1786-1875), to whom France owes the invention of wire rope suspension bridges and the tubular boiler.

In a curious work on railways which appeared in 1839, Seguin argued that if heat is energy, then when steam is employed in a steam engine some of the heat ought to be consumed and that less heat would enter the condenser than left the boiler.

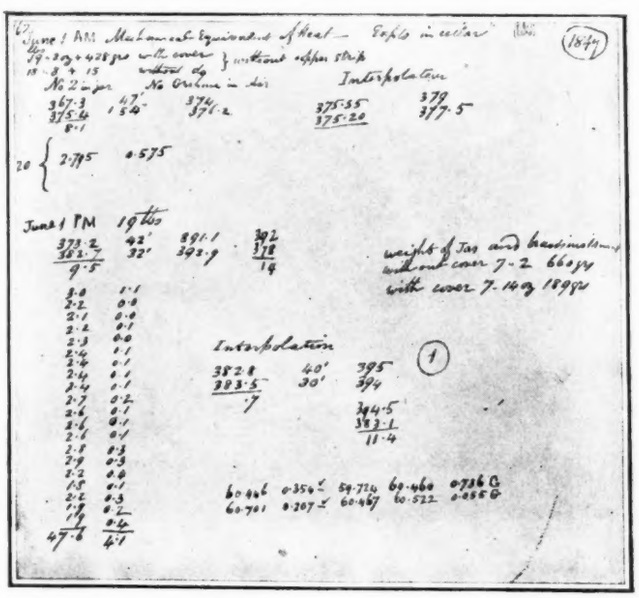
Karl Friedrich Mohr

At the same time that these French observers were recording their views, a young German chemist and druggist named Karl Freidrich Mohr had written a paper entitled "Ueber die Natur der Warme," which appeared in the *Zeitschrift fur physik* in 1837. In this the writer said: "Besides the fifty-four chemical elements there is in the physical world one agent only and this is called kraft (energy). It may appear according to circumstances as motion, chemical affinity, cohesion, electricity, light and magnetism; and from any of these forms it can be transformed into any of the others." Mohr was born in 1806 and died in 1879, having spent his life mainly in business and in teaching pharmacy at Bonn.

Julius Robert von Mayer

We now come to the important work of the forties. The first to be noticed is that of the German surgeon, Julius Robert von Mayer.

Born at Heilbronn in Wurtemburg, Nov. 25, 1814, Mayer was trained as a doctor, but before settling down in practice in his native place he served as a ship's surgeon and his memoir of 1842 "Remarks on the Forces of Inorganic Nature," was the outcome of a train of thought started when attending his patients in Java. His attention was drawn to the question of animal heat and from that to the relation between heat and work. The numerical value for the equivalent of heat he de-



A page from Joule's notebook

duced from the specific heat of air at constant volume and at constant pressure.

Tyndall, writing of Mayer's paper, said that it showed that in 1842 he was in advance of all the scientific men of his time. Mayer, absorbed as he was in the duties of his profession, was not, however, in a position to experiment. His merits were recognized, and he is justly regarded as one of the founders of thermodynamics. He

was ennobled by the German Emperor, and his statue now stands in Heilbronn where he died March 20, 1878.

Ludwig August Colding

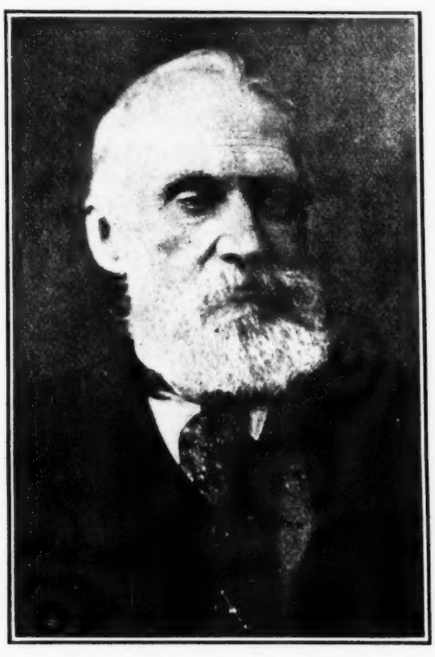
A year after the publication of Mayer's essay a further step was made by the Danish civil engineer, Ludwig August Colding, in a paper which he read to the Royal Society of Copenhagen, entitled, "Theses Concerning Forces."

In this Colding summarized the results of some 200 experiments on the heat generated by the friction of metals and other substances, and showed that to raise the temperature of a pound of water one degree Centigrade it was necessary to do as much work as would raise a weight of one pound 1,148 ft. high. A civil engineer of distinction, Colding, who was born in 1815 and died in 1888, was in the public service and was the author of many valuable scientific papers.

James Prescott Joule

Whatever the value of the work of the pioneers, to which attention has been drawn, it is generally agreed that it is all far surpassed in extent and thoroughness by that done by James Prescott Joule, who devoted ten or twelve years to an elaborate series of experiments, the importance of which can hardly be overrated.

He was from the first a very accurate investigator, and the results which he published in his four papers of 1843, 1845, 1847 and 1849, firmly established the new doctrine and led to the complete abandonment of the old caloric theory.

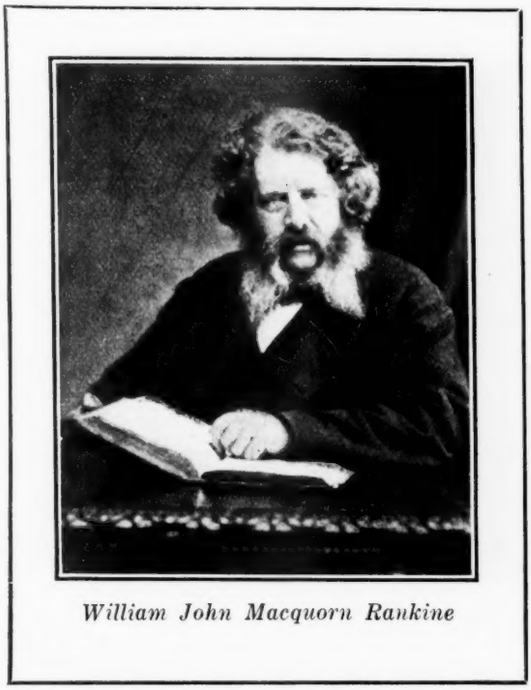


William Thomson (Lord Kelvin)

Joule was the son of a wealthy Manchester brewer and was born in Manchester on Christmas Eve, 1818. Educated mainly at home under tutors when a boy, he had the inestimable advantage of receiving instruction in mathematics from John Dalton, the author of the atomic theory.

Dalton's scientific home was the Manchester Literary and Philosophical Society, and of this Joule himself afterward served as librarian, secretary and president. It was upon Joule that Dalton's mantle fell. Emerson in one of his essays says, "The knowledge, that in the city is a man who invented the railroad, raises the credit of all the citizens."

Dalton and Joule invented no railroad, but they made wonderful additions to natural knowledge, and the high reputation Manchester enjoys as a center of scientific work is largely due to the position attained by these two distinguished men of science. This the citizens of Manchester have recognized by placing their statues in the City Hall.



William John Macquorn Rankine

William Sturgeon

Another scientific inventor connected with Manchester was William Sturgeon, to whom we owe the soft iron electromagnet and the commutator. Joule had made some of his first original experiments with Sturgeon's magneto-electric machines, and his first published paper appeared in Sturgeon's "Annals of Electricity," in 1838. The title of Joule's paper on the equivalence of heat, which he read to an "unwilling audience of six" at the Cork meeting of the British Association in 1843, was "On the Calorific Effects of Magneto Electricity."

This was followed by his papers to the same body at Cambridge in 1845 and at Oxford in 1847. The last, though it raised no enthusiasm, had the happy effect of bringing Joule into contact with Thomson, who had but recently been appointed to the chair of natural philosophy in the University of Glasgow.

Two years later, Jan. 21, 1849, Joule communicated to the Royal Society his great memoir "On the Mechanical Equivalent of Heat." In this he stated that the quantity of heat capable of increasing the temperature of one pound of water by one degree Fahrenheit required for its evolution the expenditure of 772 ft.-lb. of energy, a result that remained for thirty years

the one satisfactory determination of this important physical constant.

Joule's later work was but more elaborate and refined investigations of closely allied subjects, and in some of these he was joined by his friend Thomson.

Of the memorable meeting of Joule and Thomson at Oxford both of them left accounts which, however, differ. "I heard," wrote Thomson, "his paper read at the sections, and felt strongly impelled to rise and say that it must be wrong . . . but as I listened on I saw that Joule had certainly a great truth and a great discovery and a most important measurement to bring forward. So instead of rising with my objection at the meeting, I waited till it was over and said my say to Joule himself at the end of the meeting."

Whether this is exactly what happened, it was from this time that their friendship dated. That same year, 1847, also saw the publication of the memoir of Thomson's great contemporary Helmholtz, "Die Erhaltung der Kraft," which was afterward put into the hands of Tyndall by the German physicist Magnus with the remark that it was the product of the finest head in Europe since the time of Jacobi.

The investigations of Rankine and Clausius began a year or two later, while the first paper read to a body of practical engineers on the new doctrine of heat was that of William Siemens "On the Conversion of Heat into Mechanical Effect," to be found in the Proceedings of the Institution of Civil Engineers for 1853.

"The ideas of Joule, Macquorn Rankine, Clausius and Thomson," said Sir Dugald Clerk in his lecture, "now form so much of the basis of all reasoning upon motive-power engines that there is some little danger to the present generation of forgetting what they owe to his great group of distinguished men but principally to Joule." "Engineers," he also said, "and engine designers are most grateful to Joule, and look back on his achievements as those of the utmost intellectual and practical importance."

The life of Joule on the whole was an uneventful one. He was made a fellow of the Royal Society in 1850 and was awarded both a Royal Medal and the famous Copley Medal for his discoveries. A man of extreme modesty he once said to his brother, "I have done two or three little things, but nothing to make a fuss about."

He died at Salford near Manchester, Oct. 11, 1889, and a few years after a memorial was placed in Westminster Abbey bearing the inscription:

This Tablet is here placed near the graves of Newton, Herschel and Darwin by those who in many lands have united to perpetuate the memory of James Prescott Joule, F.R.S., of Manchester in recognition of services rendered to Science in establishing the law of the conservation of energy and determining the mechanical equivalent of heat.

New Method of Absorbing Oxygen

The discovery of a new absorbent for oxygen, to be used in gas analysis, has been announced by Louis F. Fieser, a chemist, of Cambridge, Mass. In spite of its rather imposing name—"An alkaline solution of sodium hydrosulfite containing two per cent of anthraquinone-β-sulfonic acid as a catalyst"—it is stated that this solution is not only more easily handled and reliable than the pyrogallol ordinarily used for this purpose, but is also less expensive.

In analyzing flue gases with the Orsat apparatus, the absorption of carbon dioxide is ideally simple and reliable. The caustic-soda or caustic-potash solution used for this purpose is very rapid in its action and lasts a long time. The absorption of carbon monoxide and oxygen is, on the other hand, a constant source of trouble to engineers, since the solutions used for absorbing these gases are slow and unreliable in their action. To avoid the trouble incident to the use of pyrogallol for the absorption of oxygen, some engineers have used a pipette containing sticks of yellow phosphorus submerged in water. As far as the analysis itself is concerned, phosphorus is ideal. Its action is rapid and positive, and the sticks will last for years if protected from direct sunlight by a piece of yellow paper wrapped around the pipette. Sunlight gradually turns the outside of the sticks red and makes them inactive.

For practical boiler-room use there are two objections to the use of phosphorous sticks. One is the hazard of poisoning and dangerous burns when this material is handled by anybody except an expert chemist. The other is the possibility of the sticks melting down in summer when the apparatus is used in a hot boiler room.

Suitability for Use in Orsat Apparatus

Feeling that this new absorbent might be valuable for use in the Orsat apparatus, *Power* wrote Mr. Fieser asking about its suitability for such work and the method and cost of making up the solution.

Mr. Fieser, in his reply, said that he hesitated to recommend the solution for technical gas analysis because, having an extremely low viscosity, it drained very rapidly. For speedy action the ordinary Orsat depends to a great extent upon the solution sticking to the surface of a nest of glass tubes in the pipette, thus exposing a large surface for the absorption of the gas. This objection would not, of course, apply to a gas-analysis apparatus in which the gas is bubbled through the solution. For the ordinary type of Orsat it seems possible that this objection could be overcome by pumping the gas back and forth a number of times between the burette and the pipette or by adding some sticky viscous substance to the solution. The practicability of these suggestions has not yet been determined. This reagent, like pyrogallol, will absorb CO_2. Therefore, the absorption of oxygen with it must not be attempted until the CO_2 has been removed.

To make up the solution about 30 grams of sodium hydroxide are dissolved in 250 c.c. (one-half pint) of water. After this 40 grams of sodium hydrosulphite and 5 grams of sodium anthraquinone-β-sulphonate are added, the solution being stirred until it assumes a blood-red color. It is then transferred to the absorption vessel. It is said that the necessary materials can be obtained from the large manufacturers of photographic chemicals at about the following prices: Sodium hydrosulphite, 20 cents per hundred grams; sodium anthraquinone-β-sulphonate (technical) $1.10 per hundred grams. The sodium hydroxide can be obtained at any drug store. With the limitations mentioned the reagent is said to be cheap, safe, rapid and reliable. It cannot evolve carbon monoxide and works at maximum speed up to the point of exhaustion, which is indicated by a color change.

If any readers experiment with this solution, *Power* will be pleased to learn what success they have.

Synchronous Condenser Should Not Carry All the Wattless Current

WHILE the principal operating problem is getting rid of wattless current, it is nevertheless important to do this as efficiently as practicable. Where synchronous condensers are provided for the purpose of absorbing the lagging current, it is not always advisable to load these up to such a point that the generators operate at unity power factor. Frequently, the interests of economy require that the main units also take care of some wattless current by operating at an appreciable leading power factor.

Losses caused by carrying reactive load are those due to the armature resistance, as well as increased iron and field losses. The synchronous machine of lowest armature resistance should therefore be utilized more fully on account of the former loss and that with the greatest voltage capacity, generally speaking, to take care of the smaller iron and field losses to best advantage. On the other hand, the turbine with the lowest water rate should be taxed with wattless load, from the latter consideration. Many factors therefore influence the distribution of wattless current in obtaining greatest over-all economy.

An Electric Boiler Explosion

IN CONNECTION with hydro-electric developments the electric steam boiler has established itself as a means of economically absorbing excess power. It was not until about five years ago that its use in this country and Canada began to be considered seriously, and since that time installations have been made running into hundreds of thousands of kilowatts, in sizes up to twenty-five thousand kilowatts and for voltages up to twenty-two thousand. These boilers have been practically free from serious operating troubles. Where explosions have occurred, they have been with small heating units. One of the common causes for explosions in fuel-fired boilers—low water—would, in an electric boiler cause it to become inoperative when the level of the water got below the lower ends of the electrodes.

Although explosions have occurred only with small heating boilers, the one reported in this issue shows that they may involve serious consequences as in this case, where the major portion of the boiler was thrown through three floors and the roof of the building. As pointed out in the report, the cause of the explosion was probably due to faulty installation and the design of the boiler. The boiler was of the surge type for use on a hot-water heating system, with a thermostatic control on the outflow pipe. No doubt it will appear to many readers that the weld between the flat head, which was over two feet in diameter, and the outer shell of the boiler was a weak spot in the design. Even with fifteen pounds pressure on this header it had to sustain a load of over three tons. Owing to the surging action of the boiler while in operation, there must have been a continual bending action on this right-angle joint which in time might have caused it to fail. However, the fact that the header was bulged about one-half inch shows that this part must have been subjected to pressure far in excess of that which the boiler was designed to stand. The violence of the explosion would also tend to bear out this conclusion. In the light of these facts it would seem that the reasons set forth for the cause of the explosion are logical.

Whenever explosions of electric boilers have occurred, the theory has been advanced that a gas explosion took place in the steam space around the electrodes above the water level or some other part of the system. It is claimed by some that a certain amount of electrolysis occurs, liberating hydrogen and oxygen and that there is a liability of this mixture being ignited by a spark from the electrodes. Even in the case of the boiler in question which operated on alternating current, with which it has been supposed to be impossible to decompose the water, a great deal of emphasis was laid on the gas-explosion theory. However, so far as published records are concerned, there appears to be nothing authentic to show that an explosion in an electric boiler has ever occurred from such a cause. On the other hand, apparently no one has gone to the trouble of finding out just what the possibilities are of an explosive gas formation in an electric boiler, or at least has not made it generally known. If the danger of a gas explosion in an electric boiler does not exist, it is something that should be set forth by those interested in the promotion of this equipment, and if such an explosion can occur, making the fact known will establish confidence, whereas ignoring the issue will create doubt.

Computations

THE engine machined all over may be a pretty sight to the amateur, but the practical engineer generally prefers to have machined and polished surfaces restricted to places where they serve some useful purpose. Yet the same engineer who would refuse to pay for a nickelplated frame on his engine will often waste his good time figuring the capacity of a water tank to six places of figures.

In one sense this is even worse than the nickel plate. It is a form of self-deception. Not only could there be no practical object in knowing the capacity of the tank so closely; the result obtained does not even have the abstract merit of being correct. The answer can be no closer than the measurements, which are never exact in spite of occasional claims to the contrary. Computations of tank capacity are rarely correct within one per cent, so that three places of figures (not three *decimal* places) are enough.

What the engineer needs in making computations is the same sort of good judgment the successful ma-

chinist uses in his work. The machinist uses one tolerance for a certain bushing, another for a keyway and another for an oil hole. There are two things to be considered in any computation—how close a result is really needed and what accuracy will the measurements permit? Nothing is gained by going beyond either of these limits.

The national total of time wasted in carrying computations too fine would be tremendous. Much of the fault lies with the elementary and high schools, where the students are taught to carry everything to four decimal places or to follow some other blind and utterly foolish rule. Students should be taught that no practical computation involving measured quantities can possibly be more than an approximation to actuality and that the man who ought to get all the prizes in applied mathematics is the one who can best judge how close it is worth while to come in any given case and then proceed to get that degree of accuracy with the least waste motion.

In this matter the engineer could profitably take a leaf from the book of the physicist, who puts down only the number of places he is sure of and one more for safety. The physicist who gives his result to five places when his method only warrants four, is looked upon by his fellow scientists as a bluffer pretending that his work is ten times as accurate as it really is. Incidentally, the bluff is usually called.

The matter is of practical importance to the ambitious engineer. Failure to apply this common-sense consideration to engineering computations retards the engineer's progress in three ways: It wastes his time and energy. It makes mathematical work unnecessarily hard and distasteful. Finally, it may cause technically trained engineers who happen to see his work to doubt his ability.

Other things being equal—that is, with equal mechanical knowledge, personality, ability to handle men, etc.—the engineer who has facility in practical computations will have the greater opportunity. In most of the better operating jobs the chief engineer must be able to figure all kinds of problems and get the right answer quickly, the right answer being not some imaginary "exact" answer, but one that meets the practical needs of the situation.

The Oil Industry Needs a Regulator

WHILE the idea of a monopoly of a natural resource is abhorrent to the public mind, the condition of the petroleum industry is such that some agency is needed to control output intelligently. Unlike coal, which during periods of low demand need not be mined, the owner of an oil lease must continue to drain his holdings regardless of the price obtainable. If an operator should cap his wells, awaiting the stabilization of the market, his neighbor would drain off the underground store, leaving nothing but a pumper, if not a dry well. Self preservation dictates a continuation of output even though the market quotations barely cover operating expenses.

The pipe-line buyers and refiners are not slow to take advantage of the unsettled conditions and, by refusing to take all the offered crude, drive prices below those justified by the demand for the refined products. In fact it is the usual practice to buy low-price crude and store the refined product, to be sold at high prices at a future time when the demand becomes normal.

While crude storage is practiced by all the larger producers, it is impossible to provide long-time tankage to care for all or even a major part of the daily production. In the first place the cost of the tanks exceeds the worth of the oil stored, requiring an enormous tank investment. In addition the evaporation loss over a period of any duration is so serious as to cause the remaining oil to be fit for little else than boiler oil.

There would be no general public interest in this if it were merely a battle between the oil producer overloaded with crude and the refinery overburdened with cash, but the abnormal conditions of the industry directly affect everyone. Crude oil is selling at so low a price as to cause the use of the crude, or the residium, in plants where it would not be justified under ordinary conditions. The supply of petroleum, which should be more or less restricted in use to those spheres where oil has a distinct advantage over coal, is being depleted by the unstable market, and the public continues to pay unreasonable prices for the refined products. While nationalization of the industry is not feasible, if indeed possible, some agency should be set up to regulate output and the distribution of crude purchases in more or less conformation with the demand for the refined products.

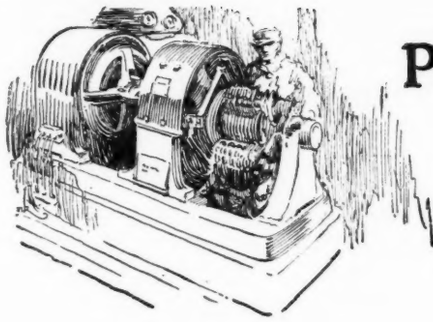
Diesel-Driven Auxiliaries

BEARING in mind that the greatest plant economy is obtained when the maximum amount of mechanical energy is obtained from the steam used to heat the feed water, stage bleeding of the main turbines is urged by most engineers. The consequence is that there is a tendency to exclude the house turbine and depend upon the main units for all auxiliary power. The point has been raised by a prominent engineer that some of the plant's auxiliaries should be driven by Diesel engines. Such an arrangement might be of twofold benefit. In the first place it is commercially inadvisable, if not dangerous, to fail to provide some means whereby the auxiliaries can still be kept in operation even if the main units drop the load, as has occurred. In addition, the jacket water of the oil engines could be used for the second feed-water heater, the water being initially heated either by a heater in the turbine outlet or by low-pressure bleeding, while the final heating would be by the engine's exhaust gases.

The thermodynamic efficiency of such a system would appear to exceed that where stage bleeding is carried on in an indefinite number of stages to approach the Carnot cycle; and it should be observed that with a proper proportion of Diesel power the station's efficiency could exceed the Carnot by reason of the low head temperature of the latter cycle in a steam plant.

The plan may possess many objectionable features, but the fact that leading engineers are studying the problem indicates that there are possibilities in the Diesel-driven auxiliaries.

The report of the World Power Conference has just been received as this issue goes to press. With three hundred papers and three simultaneous sessions no attempt has been made to cover the complete discussion. That which will be of greatest interest to American readers, however, will appear in next week's issue, and abstracts of some of the more important papers will appear as space permits.

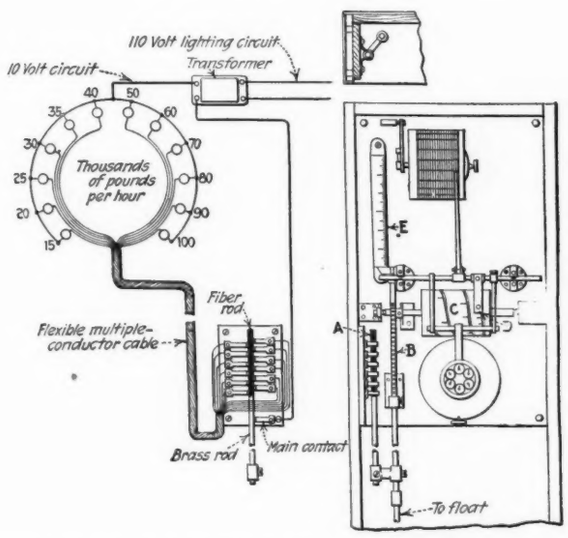


Practical Ideas *from* Practical Men

Boiler-Room Load Indicator Operated from Metering Heater

In plants in which the load varies over a wide range and necessitates the cutting in and taking off of boilers at certain periods of the day, it is desirable that some type of load indicator be installed in the boiler room to give the fireman some idea of the rate of increase or decrease of the load. The illustration shows a form of indicator which we installed recently in our plant and which has given satisfactory results.

The condensate from the main units is passed directly to a metering heater of the V-notch type, the recording and integrating part of the meter being located on the turbine-room floor directly above the heater. As the metering device is actuated through a rack connected with a float in the heater, the rise and fall of the rack is



Arrangement of indicating lamps and contacts on meter

at all times proportional to the load on the plant, and we considered this an ideal place from which to operate the load indicator.

A rod $\frac{3}{8}$ in. in diameter sliding through a series of contacts was fastened to the rack as shown in the illustration, the top portion of the rod being made of fiber and lower portion of $\frac{3}{8}$-in. diameter brass. In locating the contacts on the board, the rack *B* was raised and as the various rates of flow marked on the drum *C* coincided with the pointer *D*, a corresponding mark was made on the scale *E*. The contacts were then spaced accordingly.

The indicating part of the device consists of a series of 10-volt lamps arranged on a board conveniently located in the boiler room in plain view of the fireman.

The operation is as follows: As the water level rises in the heater above the weir, owing to an increase in load, the rack *B* moves upward, carrying with it the contact rod *A*, and as each contact is reached by the brass portion of the rod, a corresponding lamp lights up. When the maximum has been reached and the load gradually falls off, the lamps drop out one by one. A transformer is connected in the circuit to give about 10 volts through the contacts and 10-volt 5-watt lamps are used on the board. Multiple conductor annunciator cable was used in making the connections between the contacts and the lamps. The general arrangement of the contacts on the meters and the connections to the lamps will be readily understood from the illustration.

Buffalo, N. Y. C. H. HARRIS.

Underground Oil-Storage Tanks Should Be Strapped Down

In most steam plants where fuel oil is used, it is stored in concrete tanks underground. In such tanks of large size, settling and the weight of the oil and tank together may cause a crack on the wall or floor with consequent loss of oil. For this reason many prefer to use iron tanks, which require a heavy foundation with anchor or holding-down bolts as well.

A recent discussion between fellow engineers as to why such tanks should be strapped and anchored brought to my mind a recent incident of a tank used for storing gasoline. This held 750 gal. when full and was placed about $1\frac{1}{2}$ ft. below the surface of the ground on bottom land beside a brook. The land had always been flooded when the brook was high, but the brook had been covered over to prevent this flooding.

After a rain storm, when the tank was only partly full of gasoline, there was found to be a mound back of the gasoline house. This mound of earth, about eight inches in height, looked curious. However, a new supply of gasoline was added in about an hour and no further attention was paid to the mound. Everyone seemed to think this was caused by the rain settling the earth around the tank but leaving some on top, which appeared as a mound. It seemed to me as if the tank were coming up to get the air, so to speak.

A few days later it was found that the tank leaked, so the earth was dug out all around it. The pipe to the oil pump proved to be bent and leaked at the elbows. The tank was left for the night while securing barrels for drawing out the remaining gasoline. Rain came down hard again that night and the next morning the tank was found floating with both water and gasoline inside.

The leak in the pipe while the tank was under water explained the reason for water being present in the tank at times just during wet weather. Buoyancy had

caused the tank to rise with 1½ ft. of earth on top of it. The earth was light and the soil at this place all filled in, or "made land," which was saturated almost to the surface in wet weather. The tank, being almost empty, had buoyancy enough to lift it from the foundation of stone posts on which it had rested.

Now, this may sound unusual, but it brings out a point in this little conversation of engineers worthy of notice. When installing underground fuel oil tanks of any size in marshy or wet soil, use heavy foundations with straps and bolts strong enough to hold them down if empty.

It would be quite inconvenient to place the tank sufficiently deep below the surface of the street or ground for the weight of the earth above to hold it down. This would prevent pumping the oil up to the surface and proper heating and draining of the heating coils unless they were piped to a boiler room in the second or third basement of the building. The expense of sinking tanks to such depths is too great comparatively, when a good foundation will hold them.

Concrete tanks serve for some grades of fuel oil better than those of iron and last longer, but gasoline and thin oils tend to seep through the walls and become lost in the soil. They also require heavy foundations to prevent settling and resultant cracks.

Cambridge, Mass. R. A. CULTRA.

A Spare Time Job*

One day when work was slow I tried to study out a way in which the copper blades of our oil switches could be repaired.

The surface of the blade exposed to the arc when contact is made and broken is small, and it seemed an unnecessary waste to throw away the blades without making some effort to repair them, the cost of which would be small enough to make it a paying proposition.

I finally decided to cut out the damaged portion on the shaper, and drilled and counterbored holes up from the bottom for ¼-in. fillister-head machine screws. Sections were then sawed from old blades sufficiently large to allow one end and the bottom to be trued up in the shaper, the bottom of these pieces being drilled and tapped for the machine screws.

The surface of the cut out part of the blade and of the pieces that were to be set in were tinned and bolted. I heated to soldering heat and sweat soldered firmly, making sure when metal was hot that the screws were drawn tight, so as to leave as little solder in the joints as possible.

The blades were then put on the shaper and the new sections cut down to the size of the blade, finishing with file and fine emery cloth. It took a very close inspection to see where the blade had been repaired.

In repairing blades in this manner, if care is taken to cut out enough of the blade, so as to have your soldered joints about one-half inch from finger contact, there is no danger of melting the solder when the arcing takes place.

Sufficient stock should be left on the bottom of the blade to insure against bending when the switch is thrown in.

The first time the blades are repaired is comparatively expensive as about one-half the time consumed in making the repair is used in cutting out the burned portions of the blade and drilling and counterboring for machine screws. The subsequent repairs will be much less in cost.

The blades so repaired have been thoroughly tested out in service and found to stand up as well as new ones and are to be preferred to new, as the second time they are repaired the cost will be extremely low. Various methods have been tried before this to make a satisfactory repair, including electric spot welding, but were not successful until repaired in the manner above described.

Since writing the foregoing I have been furnished with a milling attachment for the lathe and find that the time taken in cutting out the burned sections of the blades is less than one-half that required to do the same operation on the shaper, making the first repair quite inexpensive. E. GEORGE.

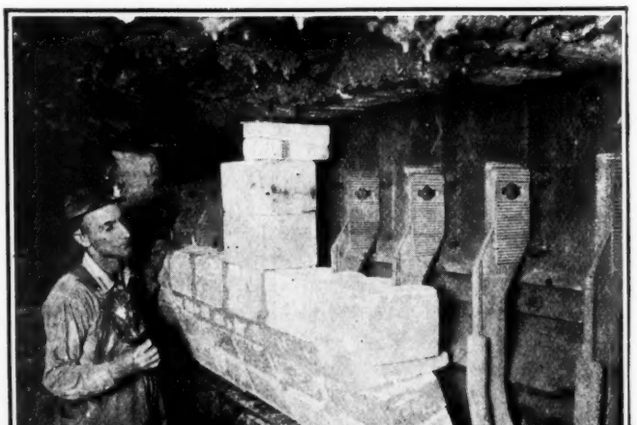
Logan, W. Va.

*Reprinted from the *American Gas and Electric Co., Bulletin* by request.

New Type of Furnace Construction

I have done a little experimenting with a furnace lining consisting of first-grade firebrick bolted flat on a cast-iron plate as shown in the illustration, and held in place with countersunk capscrews protected by two inches of cement. This gives a lining only 2½ in. thick, but it is rather surprising the way it stands up. As we are considering the possibility of adapting such a lining to a pulverized-coal furnace using hollow walls for preheated air, information would be welcomed from anyone who has been working along this line.

On a large scale, of course, the tile would be larger and possibly a little thicker than a standard firebrick, and after fastening the tile in place, the furnace would be given a thin coating with the cement gun to fill up



New way of building furnace walls

cracks. There is a real advantage in having such a lining comparatively thin, because the working face of the brick is kept cooler. A carborundum brick would be just the thing for such an application, except that it has such high thermal conductivity that it would burn the ironwork. If the erosion rate of such a wall was not over, say, ½ in. per month and the full thickness was restored each month by means of the cement gun or hand plastering (which I do not consider equal to the gun), it is obvious that the result would be highly satisfactory. GUY B. RANDALL.

Dayton, Ohio.

Comments from Readers

Smaller Furnaces for Pulverized Coal

Referring to the editorial "Smaller Furnaces for Pulverized Coal" in the June 10 issue, you raise the point that the heat liberated per cubic foot of furnace space when burning powdered coal is only about half that liberated per cubic foot when stokers are used, according to present practice. You refer to the experience of Mr. Couch at the plant of the Narragansett Electric Lighting Co. at Providence, in securing 80 per cent efficiency when liberating heat at the rate of 30,000 B.t.u. per hour, but at the expense of the brickwork. You apparently advocate smaller furnaces for powdered coal than present practice indicates or higher rates of heat liberation per cubic foot of combustion space. It would seem that you are inclined to cooling the walls either by air or water as a solution to this problem.

Excessively large furnace spaces are one of the handicaps to the extended use of powdered coal. There will be more and more work done in the future to make possible the use of smaller furnaces than have hitherto been required. However, there are some fundamental principles that need to be considered, a statement of which may indicate the direction of attack of this problem. To burn powdered coal in suspension requires time, and since the coal is in motion the time permissible for combustion cannot be greater than that taken by the coal in traversing the furnace. However, the speed of combustion depends on many things, and everything that will increase the speed will make possible the use of a smaller furnace so far as combustion alone is concerned. Speed of combustion is affected by temperature, fineness of coal particles and degree of mixture of coal and air. Fineness is dependent on the machine grinding the coal. Mixture of coal and air is dependent on the method of feeding coal into the furnace and provision for mixing. Temperature is dependent on the rate of liberation of heat and the character of surfaces surrounding the furnace.

Since the greater the furnace temperature the greater the speed of combustion and consequently the smaller the furnace permissible, it is obvious that cooling the wall in effect works just opposite to the result desired; that is, it tends to reduce furnace temperature and make a larger combustion space necessary.

It would seem, then, that the solution lies more in the use of refractories capable of withstanding higher temperatures; that is, refractories that will not soften under much higher temperatures than are now ordinarily encountered in furnace practice and will not react with slag at these temperatures.

It is along this line that the Norton Co., Worcester, Mass, is seeking a solution to this problem in conducting extensive experimental and research work in cooperation with the Sanford Riley Stoker Co. A furnace has been constructed under a 5,000-sq.ft. boiler in the power plant of the Norton Co. much smaller than present practice demands. A portion of the furnace wall has been constructed of special refractory brick and a portion of standard firebrick. A unit powdered-coal machine has been installed to supply powdered coal. It is known in advance that the temperatures that will be produced will be too great for ordinary firebrick to withstand, and the line of attack will be to study the action in this furnace and endeavor to produce a refractory that will meet the conditions imposed. It is hoped that this will result in means of greatly reducing furnace volumes required for powdered coal.

Worcester, Mass. OLLISON CRAIG,
Sanford Riley Stoker Co.

An International Puzzle

My attention has been drawn to Mr. E. S. Coutant's article in the April 29 issue entitled "An International Puzzle," and as he calls my accuracy in question, you will perhaps permit me a reply. Those of your readers who see *The Engineer* will know that the discussion arose, not from an article published by Mr. Brownlie, as Mr. Coutant states, but from a rather scathing editorial criticism of a paper read by Mr. Brownlie before the Institution of Electrical Engineers. In that paper Mr. Brownlie gave details of a series of five tests on a boiler at Lakeside for which he claimed extreme accuracy and which he largely used as the basis of his argument.

I wrote a letter pointing out that if those tests were plotted on the Parsons system, the result was such as to require explanation, for they indicated that the boiler would evaporate about 40,000 lb. of water per shift with no fuel consumption at all. The relative advantages of powdered coal and mechanical stokers has nothing to do with the question, and I have not criticized powdered-fuel firing in any way whatever.

In order to make clear the point at issue, I give in Table I the figures from Mr. Brownlie's paper which I commented upon.

TABLE I—POUNDS OF FUEL BURNED AND WATER EVAPORATED PER HOUR

Test No.	1	2	3	4	5
Fuel fired hourly, lb.	5,980	9,740	9,560	6,650	11,350
Water fed to boiler per hr., lb.	53,390	83,953	81,121	57,572	92,202

In comparing results on the basis of the Parsons lines, it is customary to adopt the eight-hour shifts as the basis, and I therefore multiplied the foregoing figures by eight in each case, with the result shown in Table II.

TABLE II—POUNDS OF FUEL BURNED AND WATER EVAPORATED PER EIGHT-HOUR SHIFT

Test No.	1	2	3	4	5
Fuel per eight-hour shift	47,840	77,920	76,480	53,200	11,350
Water per eight-hour shift	427,120	671,624	648,968	460,576	737,616

I plotted the pairs of figures in Table II on squared paper and drew a straight line through the five points, obtaining a diagram that was reproduced in the April 1 issue of *Power*. Anyone who plots the figures for himself will find, as I did, that the line cuts the base of the diagram, indicating a substantial evaporation with no fuel consumption. This is "The International Puzzle."

Mr. Coutant does not point out the error of which he accuses me, so I would ask the readers of *Power* to plot the results for themselves. The diagram that Mr. Coutant puts forward is obviously absurd. The scales are graduated in coal and water per shift respectively, yet he plots points, some of which refer to consumption per hour, and some to consumption per ten hours, and draws a straight line through the lot.

I need hardly point out that it is absolutely essential that all figures should refer to the same periods of time, or the results become of no value, for the "constant" of the line will be different for every period.

I fear that Mr. Coutant, like Mr. Swindin, has rushed in to criticise a method with which he is not conversant. I am glad to note that he does not question the fact, which is agreed by engineers who use the Parsons system in the daily operation of their plants, that the Parsons line is for all practical purposes straight and not curved, as some of the other defenders of Lakeside figures have attempted to argue.

London, England. F. D. NAPIER.

[This discussion having been prolonged in British and American publications to a point where it has ceased to be profitable, further comments on the subject are not invited. Interested readers will find an illuminating discussion of the Parsons line in the July 1 issue.—Editor.]

Furnace Linings

It is to be hoped that the articles on furnace linings in the June 17 and 24 issues of *Power* will serve to stimulate a general study and discussion of this important and little understood subject. Practice in building and maintaining boiler furnaces smacks too much of the art of the brickmason and not enough of sound engineering. On the other hand, in our first feeble efforts to get out of the frying pan we are coming very close to getting into the fire. We leave the rule-of-thumb mechanic and stagger into the arms of the alchemist, that bewhiskered wizard who, with mortar and pestle and certain mystic rites, produces special brands of high-temperature cements at fancy prices for simple-minded folk. What a blessing it would be if the

Fig. 1—Mixture of 70 per cent ground brick, 25 per cent fireclay and 5 per cent burned silica gave best results

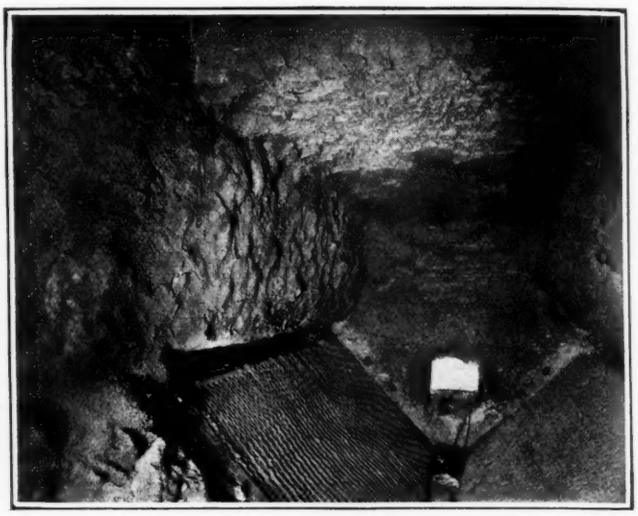


Fig. 2—Spalling occurred when 75 per cent ground brick and 25 per cent fireclay was used

law required an analysis of "Nonmelto" furnace cement on the package.

To those of us who have not been thinking, and also to those who have, the article by James Faulkner in the May 15, 1923, issue of *Power* may be read profitably in connection with the articles referred to. None of the three are necessarily to be swallowed whole, but all afford nutritious thought food.

In a broad way there are three important elements to a furnace job: (1) Refractory material; (2) bonding agent; (3) method of application. The refractory material makes up the bulk of the furnace lining. Indeed, in a new job it may constitute the whole works; as witness one might mention the firebricks of uniform size being placed on the market in recent months.

With proper design a furnace may be built of such bricks with no bonding agent at all. The writer has long practiced this with Detrick flat arches with satisfactory results. Grouting in the top of such an arch is a classical example of widely practiced lost motion. Of course such a furnace is really a sectional furnace, and the bonding is done at the brick plant in making the individual bricks. The refractory material may come in the form of a dead-burned grog such as old brickbats (or the equivalent), which have to be ground up and mixed with some bonding agent in connection with the actual building of the monolithic lining. The lining may be applied by mallet, trowel or the cement gun. In many cases there is a good deal to be said in favor of buying ground brickbats of the proper analysis from a brick company. The price is usually $8 or $9 per ton f.o.b. the point of origin.

There are a number of variations of a combination of the two methods which readily suggest themselves. In the plant with which the writer is connected three methods are followed: (1) Detrick arches are laid up dry; (2) new side walls are laid with thick joints of 75 or 80 per cent ground firebrick and a bonding agent; (3) furnaces are relined with the cement gun once a month.

The four pictures shown on page 1029 of *Power*, June 24, happen to have been taken in this plant. The text of the article accompanying those pictures is, in a broad way, a description of a method of furnace repair that is unquestionably superior to letting the

linings burn out entirely and then, perforce, replacing them or to following a nondescript method of hand patching, varied widely according to the individual patcher's judgment. There are so many variables in furnace work that each furnace problem becomes to a considerable extent a local problem. This alone puts a premium on more definite knowledge than we now possess. To make a local decision requires some local knowledge, until time and research enable us to formulate general rules.

Figs. 1 to 4 are furnaces after three weeks' operation at 165 per cent average rating with about 13 per cent CO_2. The furnaces are Dutch ovens with Detrick arches and side walls over Murphy stokers on Stirling boilers. The mixture in Fig. 1 was 70 per cent ground brick, 25 per cent fireclay and 5 per cent burned silica. This mixture gave the best results in this particular test and may be compared with Figs. 2 to 4. Notice that the front wall is practically free from cracks, spalling or fluxing. In Fig. 3 the lining consisted of 65 per cent ground brick, 25 per cent fireclay and 10 per cent burned silica. Fig. 2 shows the results when a mixture of 75 per cent ground brick and 25 per cent fireclay was used. Notice the marked effect obtained on the front wall by varying the silica. In Fig. 4 are shown the results obtained when using ground brick alone.

The pictures are shown mainly as proof that a great deal depends on the proper mixture. The ground brickbats in these cases ran in the ratio of about 58 per cent silica to 27 per cent alumina. The fireclay ran 61 per cent silica to 27 per cent alumina. The fireclay, much to our surprise, melted in the furnace somewhat below Seger Cone No. 16 (2,642 deg. F.) By going to a higher grade, or higher melting point fireclay we have greatly improved our results. For our conditions, when burning Logan and Mingo County coal, we find ground firebrick running about 53 per cent silica to 43 per cent alumina, and fireclay (high melting point) running about 66 per cent silica to 23 per cent alumina gave better results. This particular combination is used without the addition of extra silica. We have had very little trouble in making this mixture stick to glazed walls in a wood-burning furnace operating at 2,650 to 2,750 deg. F. furnace temperature when

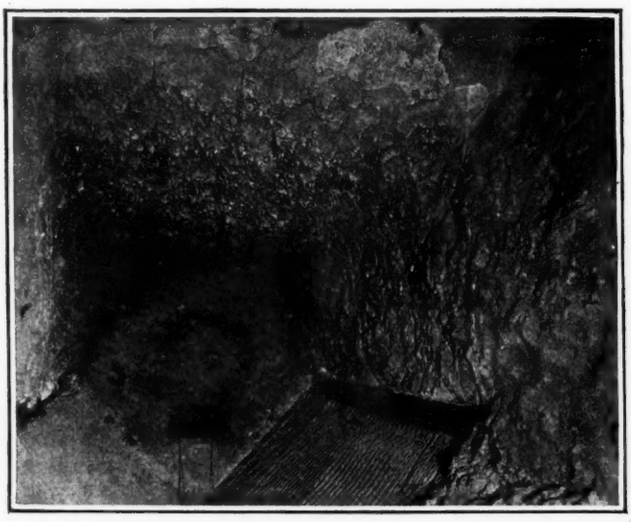


Fig. 3—When only 65 per cent brick was used and 10 per cent silica was added, tendency to crack and flux increased

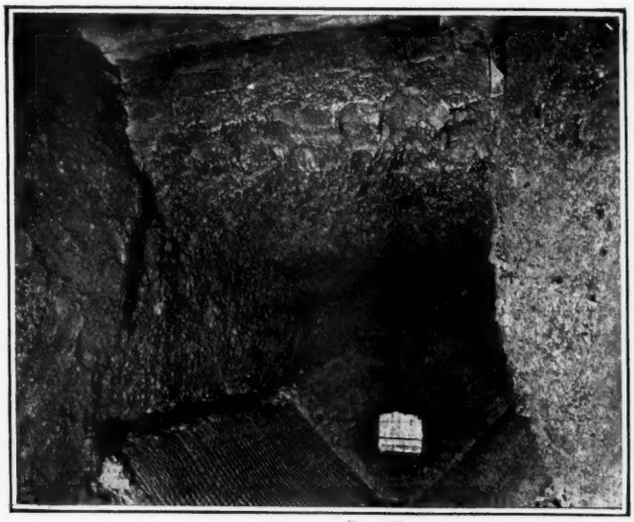


Fig. 4—Results when ground firebrick only was used

applied in ¼-in. coats with about one pound of water glass per gallon of water of hydration.

So far as side walls are concerned we have overcome the rebound trouble to a point where we can make our side wall thick and hold it there. Flat arches remain the greatest difficulty. We find it advisable and economical to shoot them, but the material does not stay put as well as in the case of the side walls.

Present furnace practices can and will be greatly improved. But such improvement will not be available to the power industry as a whole until each power plant gets much more familiar with the elements of refractories, bonding agents, fuel ash and their physical characteristics. The Seger or Orton Cone is an effective temperature indicator for refractories (better than a pyrometer) but, strange to say, not one power plant engineer in twenty knows what it is.

Dayton, Ohio. GUY B. RANDALL.

Smoke Abatement

In the May 6 issue suggestions were solicited relative to the proposed Standard Smoke Ordinance prepared by a committee representing the American Society of Heating Engineers, the Stoker Manufacturers Association, the American Civic Association and the American Society of Mechanical Engineers. In this connection I should like to quote Section 21 of the revised Smoke Abatement Ordinance of Buffalo, N. Y. This section was finally incorporated largely through the efforts of the writer and is intended to obviate favoritism. It reads as follows:

Section 21: If any person acting on behalf of the City under the provisions of the Ordinance shall take or receive any money or any valuable consideration for the purpose of favoring any person or persons, he shall be fined not less than ten dollars ($10) for each offense and shall be dismissed from the service; or, if any person acting on behalf of the City, under the provisions of this Ordinance, shall show favoritism in inspecting, or in filing complaints, or in instituting suits or in prosecuting the same for violation of this Ordinance, or shall advise or recommend the use of any particular type or make of furnace or device, or method other than proper management of furnace or furnaces, and correct firing thereof, or of any particular kind of coal, for the purpose of favoring any dealer in coal, he shall, on satisfactory proof of violation of this section, be promptly removed from office.

Buffalo, N. Y. THOMAS E. MARTIN.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Beading of Tube Ends of H. R. T. Boilers

Why is it necessary to bead over the ends of tubes in a return-tubular boiler? *H. A. A.*

When the tube ends are beaded over, their durability in resisting the action of the fire is much greater than when the ends are simply flared. However, the operation of beading, as ordinarily performed, has a tendency to injure the tube material and to impair the tightness of the joints between the tubes and tube sheets, although it may not deprive the tubes of so much holding power as to prevent their sufficient action as stays.

Location of Fusible Plug

Where should the fusible plug be located in a Robb-Mumford boiler, what is the reason for the location, and how should the water-gage glass be placed with respect to the fusible plug? *S. L.*

Fusible plugs should be placed in boilers at the lowest permissible water level in the direct path of the products of combustion, as near the primary combustion chamber as possible. For Robb-Mumford boilers regulations usually require that fusible plugs, when used, shall be located "in the bottom of the steam-and-water drum, 24 in. from the center of the rear neck which connects the main shell with the drum, and projecting through the sheet not less than 1 in." Evidently, the distance of 24 in. from the rear neck is so prescribed in order that lumping up of the water surface in the drum, due to activity of circulation through the neck, would not keep the plug cool and prevent it from fusing after the main water line had become lower than the "lowest permissible water level" for the boiler. The water-gage glass should be so placed that the lowest visible part of the gage glass will be not less than two inches above the lowest permissible water level for the boiler, and therefore not less than two inches above the position required for the fusible plug.

Pounding of Duplex Pump

We have a 12x12x12-in. duplex steam pump rated at 1,000 gal. per min., with suction lift of 13 ft. and operating against a head of about 115 ft. The suction line is 8 in. and the discharge is 6 in. This pump will operate at nearly full capacity without hammering and has some knock at very low speeds. We have cracked three water ends between the cylinders. What may be the cause of the knocking and cracking? *R. W. R*

The trouble probably is due to the ramming action of the water, more especially that in the suction pipe, when brought to rest at the ends of the strokes. This is more likely to be worse with a long suction pipe. The principal shocks from irregularities of flow in the discharge line can be taken up by an air chamber connected with the line near the pump. The air chamber should be provided with a glass gage and a pet cock on top for keeping the water level at the proper height. The ramming due to checking the velocity of the water in the suction line can be reduced to a harmless degree by the use of an air chamber in the suction line near the pump. This air chamber will act like a surge pipe for receiving and damping the velocity head when the pump is at the ends of the strokes and flow to the pump is arrested. The air chambers each should have not less than 6 cu.ft. capacity, and their connections should be directly in line with the direction of flow. A pump of the size quoted should be provided with cushion valves in the steam end for regulating cushioning on the exhaust, so the pistons may be brought to rest more gradually at the ends of the strokes. If the trouble persists with all the cushioning adjustment that is available, the builders should be consulted. One remedy would be to provide the pistons with rings as long as the faces of the pistons will permit to obtain more cushioning by earlier covering of the exhaust ports.

Voltage Between Leads and Reversing Rotation of Motors

On 220-volt alternating-current service for power, what are the various voltages between leads on three-phase and two-phase; also what voltage is obtained between any single lead of the above and ground? What is the simplest way to reverse the rotation of a three-phase motor; also of a two-phase (three- and four-wire)? *G. V. A.*

On a 220-volt alternating current three-phase circuit the voltage between the different leads will be the same. Of course there might be a slight difference due to the unbalance of the load on the system. On a three-wire two-phase system the voltage between either of the outside leads and the middle wire will be 220 volts, where the voltage between the two outside volts will be $220 \times 1.414 = 311$ volts.

On a two-phase system the neutral, or the middle wire, is generally grounded. Therefore, from either of the outside leads to ground you should obtain 220 volts, where the voltage from the middle wire to ground will be 0. The grounding of a three-phase system will depend upon the connection of the transformer wiring. If the transformers are connected in star, the neutral point will be grounded, and if you obtain 220 volts between leads the voltage to ground will be $220 \div 1.732 = 127$ volts. If the transformers are connected in delta, then the ground is usually placed on one of the leads, and in this case the voltage between two of the

leads and ground will be 220, where the voltage from the other leads to ground will be 0. Of course the power might be supplied from open-delta connected transformers, in which case the middle leg of the circuit is grounded and 220 volts will be obtained from either of the outside legs to ground, and 0 from the middle leg.

A three-phase motor can be reversed by crossing any two of the line wires. If a two-phase motor is connected to a three-wire circuit, it may be reversed by interchanging the two outside wires. If the motor is connected to a four-wire circuit, then interchange the leads of either phase for reversed direction of rotation.

Throttling Calorimeter

What is the principle of operation of a throttling calorimeter for determining the percentage of moisture in steam, and how can such a calorimeter be made for power-plant purposes? W. B. G.

The principle of operation may be explained by reference to Fig. 1. Assume that steam at 75 lb. per sq.in. absolute in a pipe at *A*, passes through the orifice *B*, where it expands to atmospheric pressure or nearly so in the pipe *C* open to the atmosphere. According to the steam tables each pound (weight) of the steam at *A* would contain 1,181.1 B.t.u. above 32 deg. F. and one pound of dry saturated steam at atmospheric pressure should contain 1,150.4 B.t.u. above 32 deg. F. Then, if there is no loss of heat, there would be 1,181.1 — 1,150.4 = 30.7 B.t.u. more heat per pound than necessary for dry saturated condition of the steam at the pressure in *C*. As the specific heat of superheated steam at atmospheric pressure is about 0.48, there would be 30.7 ÷ 0.48 = about 64 deg. of superheating at *C*, and the temperature would be 212 + 64 = 276 deg. F. However, if the initial steam at 75 lb. absolute contained moisture there would be less heat available to perform the superheating, and the temperature at *C* shown by a thermometer *O* would be less than 276 deg. F.

Suppose the temperature at *C* is 232 deg. F., or only 232 — 212 = 20 deg. F. above the temperature of dry saturated steam at the pressure in *C*. Then the heat

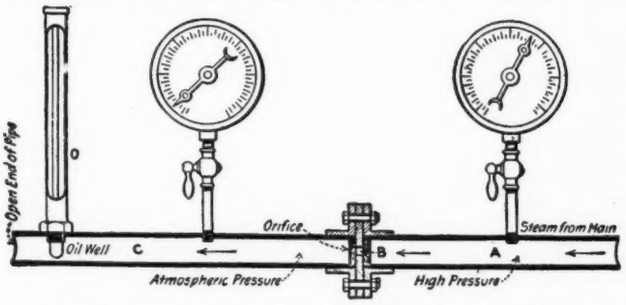


Fig. 1—Diagrammatic illustration of throttling calorimeter

that produced the superheating would be only 20 × 0.48 = 9.6 B.t.u. As one pound of dry saturated steam at atmospheric pressure, as at *C*, would contain 1,150.4 B.t.u., the total heat in one pound of the sample steam would be 1,150.4 + 9.6 = 1,160 B.t.u.

By referring to the steam tables, it may be seen that a pound (weight) of dry saturated steam at the pressure of 75 lb. per sq.in. absolute contains 277.4 B.t.u. as heat of the liquid, and if the steam in question contained only 1,160 B.t.u., there would be only 1,160 — 277.4 = 882.6 B.t.u. per pound for latent heat of evaporation. Since the latent heat of evaporation of steam at the pressure 75 lb. absolute is 903.7 B.t.u., it follows that only $\frac{882.6}{903.7} = 0.976$ of each pound of steam could have been dry saturated steam. The balance, 1 — 0.976 = 0.024 lb., or 2.4 per cent, would be water that did not receive latent heat for its evaporation.

For power-plant purposes a throttling calorimeter can be made up of ½-in. pipe and fittings as shown in

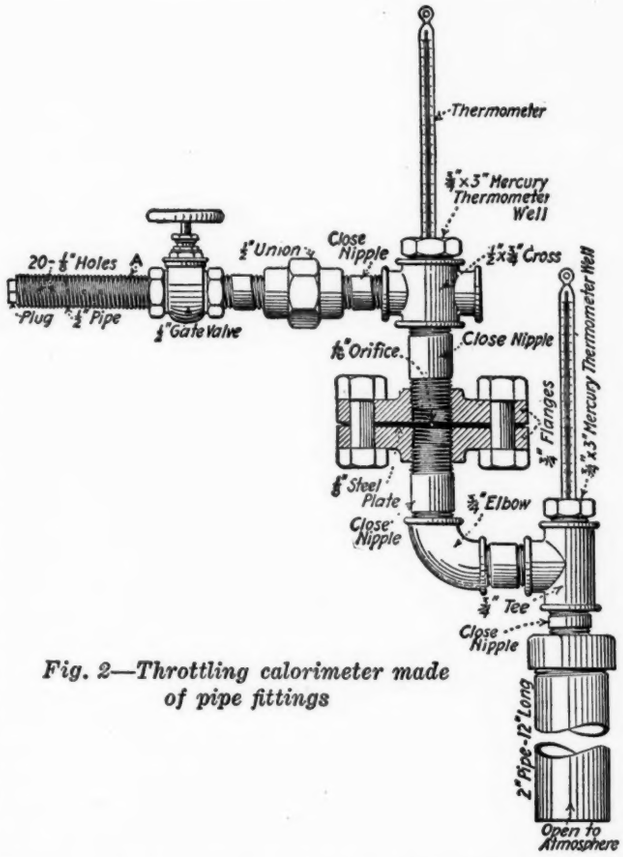


Fig. 2—Throttling calorimeter made of pipe fittings

Fig. 2. The sampling pipe *A* through which the steam is drawn from the steam main should be ½-in. pipe with long threaded extension screwed into the side of the main steam pipe within ½ in. of the full diameter of the main, closed at its end, and should be provided with at least twenty ¼-in. holes in its sides uniformly distributed, the first of which at each end should be not less than ½ in. from the wall of the pipe. The orifice for throttling the steam can be a ⅛-in. diameter hole in a plate of thin steel placed between flanges as shown in section. All connecting piping and fittings should be as short as possible and covered with a non-conducting material to reduce radiation to a minimum. The temperatures should be taken with thermometers having graduated stems. If mercury is not available for the thermometer wells, good results can be obtained by filling the wells with cylinder oil.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Ten Common Fallacies

IN ENGINEERING, as in every other field, there are certain fallacies that persist year after year in spite of all efforts to dislodge them. The ten that follow are all prevalent. Some are widely current even among intelligent engineers. Others have been pretty well cleared from the minds of engineers, but are held as self-evident truths by the general public.

These fallacies are of more than academic interest. They have a direct effect upon the economic life of the country, leading as they do to unwise decisions in important matters. The list has been selected at random and does not by any means include all the erroneous ideas that are floating around on power-plant matters. In the following paragraphs the fallacies are printed in italics and followed by a few sentences stating the essential facts of the case.

1. Heat can be obtained for nothing by decomposing water and then burning the hydrogen produced.

Everybody knows that hydrogen will burn and give off a lot of heat. It is also common knowledge that water is composed of hydrogen and oxygen chemically combined and that water can be decomposed in various ways. Unfortunately, the law of conservation of energy is on the job here as everywhere else to prevent one's getting something for nothing. It requires 62,100 B.t.u. to decompose nine pounds of water. The product is one pound of hydrogen and eight of oxygen. When the pound of hydrogen is burned with the oxygen (or with air) it gives off 62,100 B.t.u., just enough to make up for the heat originally expended in decomposing the water. The net effect is nil.

2. In a steam engine much of the power delivered to the piston by the steam is wasted because the connecting rod does not get a good "purchase" on the crank, particularly near the beginning and end of the stroke. A rack-and-pinion drive would prevent this.

The famous Peter Cooper wasted years on this wild-goose chase. Changes in leverage, gear ratio or purchase have no direct effect on efficiency. Except for friction, any combination of gears, links, cranks, etc., would be 100 per cent efficient as a power transmission. The only grain of truth in this fallacy is that the arrangement of levers may have a small effect on the amount of power wasted in friction.

At the start of the stroke the connecting rod exerts practically no turning moment on the crank. In other words, practically no power is then being delivered to the crank, but neither is the steam delivering any appreciable amount of power to the piston, which is practically stationary. Neglecting friction and the inertia of moving parts, the power delivered to the crank at any moment is equal to that delivered to the piston by the steam. The inertia helps at some points of the revolution and hinders at others, the net effect—so far as efficiency is concerned—being zero.

3. A compound engine is more efficient than a simple engine because it expands the steam twice.

Compounding increases efficiency because it reduces cylinder condensation, thus permitting advantage to be taken of a large ratio of expansion. Were it not for this, a single cylinder of the same dimensions as the low-pressure clyinder and taking the same *weight* of steam per stroke, would give the same efficiency. Moreover, it would develop the same power.

Since the compound engine finds practically its sole reason for existence in the reduction of cylinder condensation, which makes possible a large ratio of expansion, any other means of reducing cylinder condensation tends to render compounding unnecessary. The most notable advance along this line has been the unaflow engine. Superheating in (reciprocating engines) has the same purpose.

4. It takes a lot more coal to generate high-pressure steam.

With the feed water at 200 deg. in both cases, it takes only 4 per cent more heat to generate a given weight of steam at 150 lb. gage pressure than at 5 lb. It must be remembered that this extra heat is in the steam, so that 4 per cent less steam would be required to do a given amount of heating. From these two considerations it might appear that the steam pressure had no effect at all upon the amount of coal required to produce a given amount of heat in the form of steam. Ordinarily, however, higher pressure would require slightly more coal because of the somewhat higher flue temperature.

5. Most of the loss in a steam engine is due to friction of the parts.

Actually, the loss due to the heat rejected in the exhaust is several times as great.

6. Since CO_2 is the product of complete combustion, a high percentage of CO_2 in the flue gas indicates complete combustion.

A higher *percentage* of CO_2 does not mean that any greater *weight* of CO_2 is produced from a pound of coal. It merely means that the sample is diluted with a smaller amount of excess air. If, when burning coal at a given rate with forced draft, a hole were opened in the upper part of the setting, the amount of CO_2 produced would not change at all. It would continue to be (as always) 3.67 lb. for every pound of carbon completely burned. However, the additional air leaking in through the hole would dilute the flue gas so that it would show a smaller per centage of CO_2.

It is much like making lemonade. Two housewives may each use six lemons in making up batches of lemonade, but the batch that contains the larger amount of water will show a smaller *percentage* of lemon, although containing the same *amount*.

7. A lot of heat is wasted in evaporating the moisture contained in coal.

The heat so lost is small. For a 12,500-B.t.u. coal containing 5 per cent of moisture it is one-half of one per cent of the heat in the coal. The largest moisture loss is that caused by the burning of the hydrogen in the fuel, since each pound of hydrogen produces nine pounds of water. This loss may reach 3 or 4 per cent with high-volatile coals. Of course the heat brought in by hydrogen far exceeds the additional moisture loss.

8. Steam is visible and white like a cloud.

Real steam is as invisible and transparent as air whether it be superheated or saturated. When steam blows into the air, it starts to condense as fine particles of liquid water. These are visible.

9. The way to cut down the excess air in operating a boiler is to cut down the air.

This may sound like a self-evident truth, but it is really a fallacy. The term "excess air," as ordinarily used, means the ratio by weight of the excess air to that actually entering into the combination, expressed as a percentage. If, when the flow of air is cut down, the actual rate at which the coal is burned is reduced in the same proportion, the *percentage* of excess air will not change at all. With oil or powdered fuel where the rate of combustion is fixed by the rate of fuel feed, cutting down the air without changing the fuel feed would, of course, reduce the percentage of excess air. With solid fuel on a grate a reduced flow of air will immediately result in less fuel burning. This reduction may or may not be in proportion to the reduction in air supply. The sure way to reduce the percentage of excess air is to stop up holes in the fire and leaks in the setting, since this will cut down the amount of air without reducing the rate of coal burning.

10. Water power costs nothing since water is free.

The fallacy of this is evident to every engineer, yet it is surprising how easily the public forgets the enormous expense in dams, land for storage, buildings, turbines, penstocks, transmission lines, etc., that in many cases makes the actual cost of water power greater.

Sixty Thousand Kilowatt General Electric Turbine for Commonwealth Edison Co.

OF THE three 60,000 kw. turbo-generator sets to be installed in the Crawford Avenue Station of the Commonwealth Edison Co., of Chicago, the illustrations show the unit that is being built by the General Electric Co. The photographs were taken in the Schenectady works during the erection on the test floor, and there is every indication that the set will be installed and in operation by October of this year.

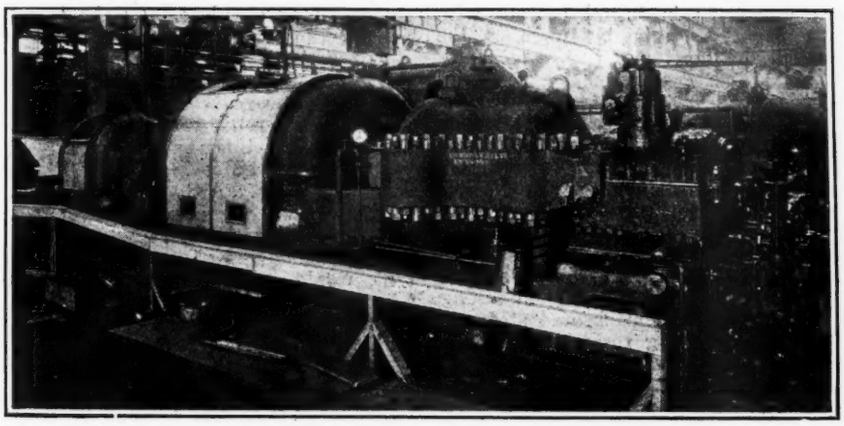


Fig. 1—High-pressure side of the unit

The unit is a cross-compound assembly, being made up of a high-pressure turbo-generator and a low-pressure turbo-generator into which the high-pressure exhaust enters after being resuperheated. The rating temperatures and pressure of the unit are divided between the two machines as follows:

	High-Pressure Side	Low-Pressure Side
Rating, kw.	17,000	43,000
Speed, r.p.m.	1,800	1,200
Initial pressure, lb. absolute	550	110
Initial temperature, Deg. F.	725	725
Exhaust pressure, lb absolute	110	0.5
Stages	10	14
Weight, lb.	196,000	716,000

In addition to the main generator the high-pressure turbine, Fig. 1, is direct connected to a 2,000-kw. house generator which is to supply station lighting and power for the auxiliaries. Exciting current for the entire unit is obtained from a direct-current generator direct connected to the low-pressure turbine.

So large are the machines, the high-pressure unit being 58 ft. long and the low-pressure machine 62 ft., that the armatures will be shipped in parts and assembled, and the first electrical tests made at the Crawford Avenue station.

Control mechanism is arranged so as to provide maximum protection against any operating difficulties. The medium used is oil under pressure, and a lack of pressure at any time due to breakage of pipes or failure of pumps will cause the steam valves to close, shutting down the machine.

The controlling mechanism on the high-pressure unit is the same as that on any of the large General Electric turbines. The main operating governor, through a pilot valve and a hydraulic cylinder, operates the main controlling valve. The emergency governor, at 10 per cent above normal operating speed, actuates a small trip valve, which in turn closes the main controlling valve by operating a dump cylinder; it likewise operates another trip valve, which closes the main throttle valve.

The low-pressure turbine has no throttle or controlling valve, but the steam coming from the reheater to the turbine flows through an intercepting valve, which during normal operation is held open by oil pressure in a cylinder. This valve is closed by the action of an operating governor on the low-pressure turbine if the speed of this unit rises to 6 per cent above normal. If the speed drops, this valve is reopened. Steam-flow control to compensate for changing loads is taken care of by the operating governor and controlling valve on the high-pressure unit, so that the intercepting valve has no partial opening position.

The emergency governor of the low-pressure machine is conected to close the intercepting valve at 10 per cent above normal speed should the operating governor of the low-pressure unit become inoperative. This same emergency governor is also connected to a trip cylinder on the high-pressure throttle valve, so that steam on the entire set is shut off if the low-pressure unit overspeeds.

It is perhaps significant that the world's largest turbines are of the compound or multi-cylinder construction. As units have increased in capacity since the introduction of the steam turbine, compound types on many past occasions were constructed as representing the largest attainable capacities, only, however, at a later date to be superseded by a single-cylinder design of even greater power.

The last blade rows must pass the greatest steam volumes and therefore contain the greatest areas. Blade lengths are limited by their ability to resist centrifugal force. Strength of material therefore determines the greatest practicable exhaust-blade area, and hence the limit in size of any given type of turbine. Here is a single-flow, low-pressure element passing the steam for a 60,000-kw. unit. This suggests that a single-cylinder 60,000-kw. unit may some day supersede the present record capacity of 50,000 kw. in a single casing turbine.

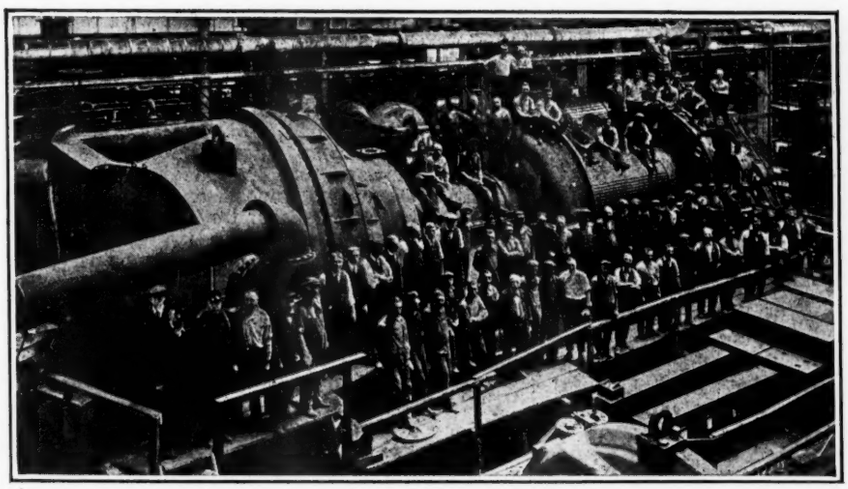


Fig. 2—Low-pressure machine, showing blanked exhaust outlet

The bolted flanges of the high-pressure casing are a foot thick, indicating that the 550 lb. pressure was much more difficult to hold than the present-day standard of 300 pounds.

How much more dangerous will be the new "high pressure"? As a matter of fact, 550 lb. is but little removed from 300 lb. in its ability to do damage if expanded to atmospheric pressure;

only about one-fifth more work would be available. By keeping temperatures at their present values, higher pressures in reality are of but little greater consequence. Even 2,400-lb. steam would be within a small percentage of 550 lb. in its available energy if expanded to atmosphere.

The character of the condenser cooling water available at Chicago, containing as it does a high percentage of sediment, prompted the designers to make use of a vertical-type condenser in preference to the usual horizontal type. The low-pressure exhaust passes

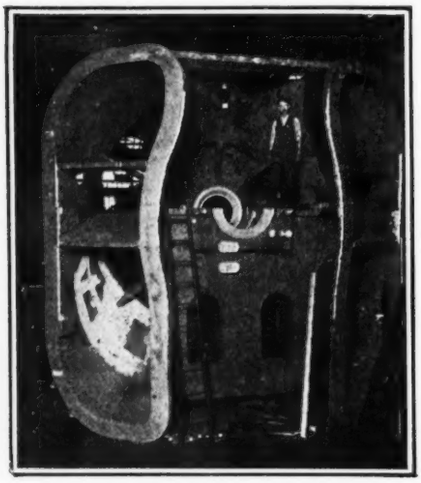


Fig. 3—Exhaust connection to condenser

out through a double passage connection around the turbine shaft, to the condenser, which stands at the end of the turbine. While the condenser design is a novelty in steam-plant practice, it should possess the advantage of giving a constant gravity head to the water regardless of the amount passing through the tubes.

Workmen's Compensation Award Denied

By A. L. H. Street

A stationary engineer's death did not result from personal injury by accident, within the meaning of the Workmen's Compensation Act, so as to entitle his dependent relatives to an award under that act where he died of pneumonia following reduction of his power of physical resistance through being overcome by heat while cleaning boilers. This is the substance of the decission handed down by the Kansas Supreme Court in the case of Hoag vs. Kansas Independant Laundry, 215 Pacific Reporter, 295. The court said:

"The workman was an engineer of experience and was engineer at this plant, in charge of operating and cleaning the boilers. Therefore he knew about the heat of the boilers. On this occasion the heat was excessive. Excessive in relation to what? Either in relation to the unusual temperature when the boilers were cleaned, or in relation to ability to withstand the heat incident to cleaning the boilers. In either case the engineer was inattentive to or misjudged the effect of the temperature on his power of endurance. For this reason what happened to him was unexpected, and if what happened had been identifiable injury then occurring, the event could not have been described as personal injury by accident.

"The heat of the boilers overcame the workman. It did not overcome him to the extent of prostrating him, but it disabled him. The disability consisted in weakened power of physical resistance to pneumonia micro-organisms, which at once became active, causing pneumonia, of which he died seven days later. He did not unexpectedly come in initial contact with pneumonia bacteria by washing the heated boilers, as the workman's wounded foot came in contact with infectious matter in foul water, and the pneumonia bacteria were not intruded into his system by washing the heated boilers, as the workman received typhoid bacilli in drinking water. There was no definite physical lesion producing a specific kind of disability, such as occurs in heat stroke. There was nothing resembling the sudden hyperemia which resulted from taking ice water into a superheated stomach. There was nothing resembling hernia, bringing a surgical operation and milk leg in its train. Disease-producing bacterial activity was stimulated by a favorable condition; the favorable condition was lowered physical resistance to cause of disease; the lower physical resistance was produced by work in excessive heat; and in the last analysis the question is whether unexpected reduction of resistance to a bacterial disease, resulting from performing work under some misjudged or ignored circumstance or condition, constitutes personal injury by accident. The court is of opinion the question should be answered in the negative.

Pneumonia may follow a surgical operation and may follow the breaking of a limb. The shock lowers vitality to such an extent that militancy of the bacterial prevails. Lowered vitality may also come from exhaustion from heavy work, from fatigue, from long hours of work, and from a great variety of other causes which expose a workman to pneumonia and other diseases. The result is there is a twilight zone between clear personal injury by accident, which is covered by the Compensation Act, and sickness, which is not covered."

Electric Boiler Explosion

On Feb. 5 of this year an electric heating boiler exploded in Winnipeg, Manitoba, Canada, as reported in *Power*, April 22. After the explosion a number of conflicting theories were advanced as to the cause. However, sufficient information has been made available to indicate that the accident was probably due to defects in the installation and a flat welded header on the boiler. In construction the boiler consisted of an outer vertical cylindrical shell which acted as a hot-water boiler into which was immersed another vertical cylindrical shell which contained the heating electrodes. The two shells were connected at the top end to a flat header, which was welded to the outer shell. There was a space of about one inch between the inner and outer shells. Steam was produced by electric current at 550 volts in the inner shell and forced the hot water out into the outer shell and through the heating systems. According to a report made on the explosion by R. A. Stewart of Winnipeg, the expansion tank on the system was about 25 ft. above the boiler so that about 10 or 12 lb. of steam pressure would be required in the inner shell to cause the water to circulate through the system. The steam produced in the inner chamber could not pass through the heating system, but was effective only in causing the water to circulate. As the steam pushed the water level in the inner chamber down, less of the electrodes were immersed and the rate of steam generated was reduced. There was an automatic air relief valve on the boiler and also a thermostatic-controlled valve on the outer-flow pipe to the heating system. Although 15 lb. was a safe working pressure, the boiler was not equipped with a safety valve, as it was considered that the expansion tank would take care of any excess pressure.

The electric boiler was a new installation and had been connected into the header of an old cast-iron fuel-fired boiler, the use of which was discontinued after the electric equipment was installed. When the explosion occurred, the boiler had been in service only about ten days. During this period it is understood that considerable trouble was experienced due to water hammer, which at times was severe.

It is claimed that when the house became warm and the thermostatic-controlled valve on the out-flow pipe closed, this would stop or retard the flow of the water through the system and it would have to back up into the expansion tank. Owing to the location of the connection for the expansion tank and the sudden reduction of area from 3 in. for the flow line to ¾-in. pipe to the expansion tank, the flow would be suddenly retarded, creating water hammer, and a back pressure that would be reflected back to the boiler and raise the water on the electrodes, causing more steam to be generated and increasing the pressure in the steam chamber. If this continued for any length of time, the pressure would increase to a point where something would have to give way. It appears from examining the top header that this was the cause, since the header was found dished out about ⅛ in. In doing this an excess strain was thrown on the welded joint between the outside shell and the flat cover plate, and caused the weld to give way.

As a result the force of the explosion was intensified upward to an extent that caused the inner chamber, electrodes and head cover to go through three floors and the roof of the house and out into the air, probably fifty to one hundred feet. Although at first one of the theories advanced was that the explosion was caused by the dissociation of water into gas, which was ignited by an electrical spark, the foregoing explanation would seem to be more rational, particularly in the light of the fact that there appears to be no definite proof that a gas explosion has ever occurred in an electric boiler.

Recent Publications

Contributions to the History of Engineering and Industry (Beitraege Zur Geschichte der Technik und Industrie). Yearbook of the Verein Deutscher Ingenieure (V.D.I.), Volume 13, 1923. Published in German by Conrad Matschoss, Berlin, Germany. Paper binding; 7½ x 9¾ in.; 147 pages; 64 illustrations. No price stated.

This annual publication is of general engineering interest. It touches the field of *Power* only indirectly in describing the early experiences that led up to the development of the modern electrical switching equipment manufactured by the German firm of Voigt & Haeffner. Its contents include the following topics: Earliest use of ordnance; the work of the chemist, Justus Liebig; the history of the Suez Canal; biography of H. Voigt; the growth of the Heckmann Copper Industry, from smithy to the manufacture of a complete line of industrial process apparatus; development of the typewriter up to the year 1900; history of chocolate and chocolate manufacturing.

Super Steam Pressure (Hoechstdruckdampf). By F. Muenzinger. Published in German by Julius Springer, Berlin, Germany, 1924. Paper binding; 6½ x 9½ in.; 140 pages; 120 illustrations. No price stated.

No other innovation in steam-engineering practice has aroused such widespread interest as the use of working pressures from 1,200 to 1,500 lb. The author of this book seeks to present an unbiased analysis of the progress made during the last three years and to review the future possibilities from both an engineering and an economic point of view. The text is profusely illustrated with graphic diagrams and curves, supplemented by explanatory notes that are helpful to the reader. The important sections of each chapter are briefly summarized and printed in wide-space type.

In the interest of safety the close co-operation between the metallurgist and the boiler manufacturer is urged to secure better materials. Likewise there is an immediate need for reliable experimental data on the properties of steam above 230 lb. High-pressure boilers operate under such different conditions that it does not appear logical to follow existing designs in every detail. As examples of radical departures from standard practice the Atmos Boiler, the Benson Process and the suggestion by Dr. Ruth to generate high-pressure steam in coils surrounded by vapors of a liquid that has an exceedingly high boiling point, are described. Cost is a deciding factor. Since the construction of the drums is the most expensive item, it follows that high-pressure boilers of the future will have fewer drums and more tubes. It may even be more economical to provide an entirely independent, external water-storage space for fluctuating loads with high peaks. A number of the most recent European boilers designed for pressures up to 16,500 lb. are shown, which are characterized by deep tube banks, and small-diameter drums out of direct contact with the furnace gases. Air preheaters, while able to utilize only about 70 per cent of the waste heat absorbed by economizers, are much cheaper than the latter and secure so great a gain in the over-all efficiency that economizers may generally be dispensed with. It may be conservatively stated that an increase in the steam working pressure from 225 to 1,500 lb. will result in a net saving of 14 per cent in the net cost of a kilowatt-hour. Additional fuel saving is also possible by interstage reheating, but this is accompanied by decreased boiler capacity.

A chapter is devoted to a discussion on heat balance, heat storage and the application of temperature-entropy diagrams. In conclusion, the Emmet Mercury Vapor Turbine at Hartford, as described in *Power*, is reviewed and cited as a parallel effort to increase power-plant economy without resorting to extremely high pressures.

The book, while largely of a critical nature, is written in a live and interesting manner by a recognized authority on steam, and for this reason will doubtlessly be well received by American engineers.

High-Pressure Steam (Hochdruck-Dampf). Published by V. D. I. Verlag G. M. B. H. Berlin S.W.19, 1924. Paper; 9x11¾ in.; 216 pages (108 of text and 108 of advertisements); 254 Illustrations and curves and numerous tables. Price, 9 marks.

This book is based on the high-pressure (steam) sessions held Jan. 18 and 19, 1924, by the V. D. I. (Society of German Engineers) in Berlin, and includes, in more extended form, material that has already appeared in the *V. D. I. Zeitschrift*. In addition to the brief speeches with which Dr. Klingenberg, president of the V. D. I., introduced the two sessions, there are fifteen technical papers dealing with various phases of the subject. Freely translated and somewhat condensed, the subjects are as follows: Technical and economic aspects of high-pressure steam (9 pages), by Friederich Münszinger; boiler materials (7 pages), by P. Goerens; Modern boiler construction (5 pages), by F. Loch; investigations on practical boiler operation (18 pages), by M. Guilleaume; principles and utilization of high-pressure steam (7 pages), by E. Josse; discussion of papers (11 pages); new ways of conserving energy (9 pages), by F. P. Löffler; high pressure and energy conservation (4 pages), by H. Gleichmann; present state of high-pressure applications (11 pages), by O. H. Hartmann; high pressures and superheat (7 pages), by W. G. Noack; tests of a noncondensing turbine in a sugar refinery (4 pages), by E. Josse and A. Stodola; control of boiler-feed water by microphotography (3 pages), by August Holle; valves and piping for conditions up to 1,500 lb. and 850 deg. F. (3 pages), by Franz Seiffert; new valves for high pressures and temperatures (7 pages), by G. W. Koehler; bibliography of boiler articles.

Full of the latest information on the problems associated with the use of high-pressure steam, this book should be in the possession of all manufacturers of boilers, valves, turbines, etc., who are interested in the newer developments.

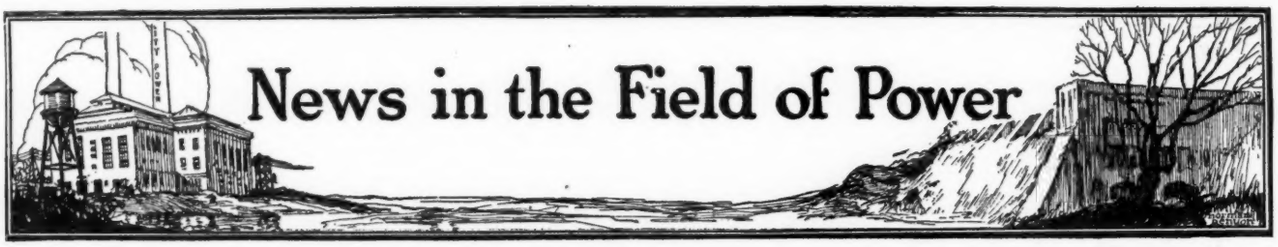
Industrial Physics—Heat. By L. Raymond Smith, Instructor in Industrial Physics, Wm. L. Dickinson High School, Jersey City, N. J. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York. Cloth; 5x7½ in.; 283 pages; 274 illustrations. Price, $2.

This is the second of a series of textbooks on Industrial Physics. The first volume, "Mechanics," was published in June, 1922. This series is designed particularly for the use of students in technical, industrial, vocational and evening schools. The treatment throughout is elementary and easily followed, with a considerable proportion of descriptive matter. The first eighty pages discuss briefly the principles of heat, energy, temperature, expansion, evaporation, fuels, etc. Seventy pages are devoted to boilers, engines and turbines. After a chapter on internal-combustion engines, the remaining chapters are devoted to the automobile, which is described in detail in a very practical manner. While designed primarily for resident students, the volume should be of assistance to those engineers who have need of an elementary treatise.

The American Engineering Standards Committee has recently issued its 1924 year book. Included in it is a progress report on standardization projects. Those of especial interest to *Power* readers are: "Elevators," (undertaken but no work started); "Safety Code for Elevators and Escalators," (draft proposals under consideration); "Safety Code for Mechanical Refrigeration" (sent out for criticism); "Pipe flanges and Fittings" (draft proposals under consideration); "Shafting" (sent out for criticism); "Safety Code for Compressed air Machinery" (project undertaken but no work started); "Electrical Safety Code" (revision).

Condenser Tubes, by Willlam R. Webster, is the reprint of a paper presented before the Metropolitan Section of the A.S.M.E., Nov. 8, 1923. It contains information concerning the manufacture of condenser tubes and also takes up the causes of failure of tubes and points out the desirability of a thorough investigation of the operating conditions as a means of providing data looking to the solution of the problems of tube failures. It is published by the Bridgeport Brass Co., Bridgeport, Conn.

United States Government Specification for Lubricants and Liquid Fuels and Method for Testing. Federal Specification Board, Standard Specification No. 2c. Technical Paper 323A, Bureau of Mines. To be had from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents.



West Nanticoke, Pa., To Have New Steam Plant

The Luzerne County Gas & Electric Corp., Kingston, Pa., which supplies electric service to anthracite-coal districts north, south and west of Wilkes-Barre, Pa., has retained Stone & Webster, Inc., Boston, Mass., to design and construct a steam plant for central-station service. The initial development will include a 20,000-kw. turbo-generator and four 17,260 sq.ft. boilers. The station will be located at West Nanticoke, Pa., on the Susquehanna River, opposite Wilkes-Barre.

California Edison Co. Feels Drought

The extent of the drought in California is indicated by the fact that the Southern California Edison Co.'s storage in Huntington Lake is only 20,000,000 acre-feet, approximately one-fifth of the amount that would have been accumulated during a normal year. The company's situation, however, is helped greatly by the fact that its plant No. 3 was brought in last year. The flow of the San Joaquin, on which it depends, holds up fairly well independent of storage.

The company is pushing the work on the tunnels that will divert the South Fork of the San Joaquin at Florence Lake into Huntington Lake. Those in charge of the driving of the 13 miles of tunnels expect to "hole through" about April 1.

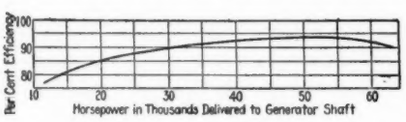
Combining New York Companies

The Rockland Light & Power Co., of Nyack, Rockland Co., N. Y., has made application to the Public Service Commission to acquire stock of the Orange County Public Service Co., Inc. The Orange County company is the owner of various hydro-electric sources of supply, some of them developed and some undeveloped. The Rockland company is anxious to acquire these plants to augment its supply of power for sale and distribution of electricity in various municipalities served by it. The petitioning company also intends to connect its lines with those of the Orange & Rockland Electric Co. and the Orange County Public Service Co. to secure better and more economical operation. The Rockland Light & Power Co. has its headquarters at Nyack and has steam plants at Orangeburg and Hillburn. The Orange County Public Service Co. has its headquarters at Middletown and operates steam plants at Middletown and Port Jervis, and hydro-electric plant at Mongaup Falls and Cuddebackville.

Official Test Made on No. 5 Turbine at Queenston

Great interest has been shown all over the world in the installation of hydraulic turbines of high power at Niagara Falls. These include the 37,500-hp. units in the plant of the Niagara Falls Power Co., two of which were furnished by the Wm. Cramp and Sons Ship and Engine Building Co. and one by the Allis-Chalmers Manufacturing Co.; the 55,000- and 58,000-hp. turbines in the Queenston plant of the Hydro-Electric Power Commission of Ontario, two of these units having been furnished by the Wellman-Seaver-Morgan Co., of Cleveland, O., three by the Cramp company and four of the same design furnished by the Dominion Engineering Works, limited, of Montreal, the Cramp company's Canadian licensee; and also the three 70,000-hp. turbines recently installed in the Niagara Falls Power Co.'s plant, two of which were furnished by the Cramp company and one by the Allis-Chalmers Manufacturing Co.

The efficiencies secured on the 37,500-hp. turbines were published in *Power* March 22, 1921. These curves show for all three units a maximum efficiency of 93 per cent. The figure shows the official test efficiency curve from the



Efficiency curve for 55,000-hp. hydraulic turbine

No. 5, 55,000-hp turbine designed by the Cramp company for the Queenston station of the Hydro-Electric Power Commission of Ontario. This unit runs at 187.5 r.p.m. and operates under a 305-ft. head. From the curve it can be seen that this turbine gave a maximum efficiency of 93.3 per cent, an efficiency of 93 per cent or over for a range in power between 44,000 and 55,000-hp., and an efficiency of 90 per cent or over for a range in power between 31,000 and 63,000 hp. Those results correspond closely to those obtained for unit No. 4 and published in *Power* July 24, 1923. It is probable that the results secured, as shown by this curve, both in peak efficiency and in average efficiency, constitute a record so far as any published results are concerned. The input to the turbine was measured by the Gibson time-pressure method. The curve was signed by the late Walter J. Francis, who at the time of his death was president of the Engineering Institute of Canada and was head of the consulting engineering firm of Walter J. Francis & Co., which was engaged by the Royal Commission of Inquiry.

Results of this kind indicate that the Francis turbine has been perfected to such an extent in this country that about as high efficiencies are being obtained as may be expected, and it is hardly likely that they will be exceeded by any considerable margin in future years for units of this type. The securing of a peak efficiency as high as 93.3 per cent and also the efficiency for the entire range of power has been brought about by a careful study of each element of the turbine which contributes to the efficiency. It is expected that the three 70,000-hp. turbines of the Niagara Falls Power Co. will be tested some time in the near future, and it will be interesting to see whether the increase in size of these units and modifications in certain features of the turbine and draft-tube design, will result in a further increase in the efficiency.

Miami Fort Power Station Progressing

Construction on the Miami Fort electric generating station, at the Junction of the Big Miami and Ohio Rivers, near Cincinnati, of the Columbia Power Co., a subsidiary of the Columbia Gas & Electric Co., Cincinnati, is progressing rapidly. The third section of the large condenser well was completed during June, and various orders for equipment were placed during the month for water softening and treating plants, hydraulic valves, feed-water heaters, deaërating apparatus, etc.

Ben Nevis To Have Water Power Development

A scheme for harnessing the watershed of Ben Nevis, which is 4,406 ft., the highest mountain in Great Britain, has received the sanction of Parliament according to press reports. The scheme, it is said, will change the face of the neighboring country and convert the little township of Fort William into a city of 12,000 inhabitants. The work will probably begin this summer and will take three or four years to complete. This project is being carried out by the North British Aluminum Co., a subsidiary of the British Aluminum Co., Ltd., London. Under the Trades Facilities Act the government is guaranteeing £2,000,000 for the project.

The engineers will have to construct a tunnel 15 miles long and 16 ft. in diameter, 300 ft. below the surface of Lock Treig to Fort William, as a preliminary. It is expected that 75,000 hp. will be developed.

Westinghouse Turbine Blading Plant To Be Moved

The entire turbine blading department of the Westinghouse Electric & Manufacturing Co., now at East Pittsburgh, will be moved to Lester, Pa., the South Philadelphia works of the company, where two new buildings are being constructed for it. This move is being made so that the entire turbine assembly will be in one plant. It is expected that the new plant will be in full operation by Oct. 1.

Carnegie Steel Co. Completes Byproduct Coke Plant

The Carnegie Steel Co. has just completed what is said to be the largest byproduct coke plant in the world, at its Clairton, Pa., works. It has been in course of construction for about two years and supplements the original byproduct coke plant at this place. The new plant consists of 366 ovens and has a daily capacity for the carbonizing of 8,500 tons of coal, producing in this period a total of 6,000 tons of cokes and 55,000,000 cu.ft. of gas. It is proposed to develop the new works to their maximum capacity as soon as the conditions warrant.

Recommends Diesel Engines for Government Boats

The advisory committee appointed by Rear Admiral Benson of the United States Shipping Board, as announced in *Power*, July 1, page 37, to recommend the most suitable types of engines for the conversion to Diesel propulsion of Shipping Board vessels has concluded its work and submitted its final rpeort.

Predicated on an initial conversion program comprising twelve large single-screw freighters, the committee unanimously agreed that this first step should be characterized by the utmost reliability, and accordingly recommended that only slow-speed direct-connected engines of proved types be used.

While recommending well-tried engines for immediate installation, the committee pointed out the desirability of encouraging the development of the double-acting engine, and in view of its great advantages there is no doubt that this type will receive due consideration in the near future. Plans and specifications are now in the course of preparation, and it is intended to place contracts as rapidly as possible.

New York Steam Corporation Enlarging Territory

The New York Steam Corp. has recently been offering stock for sale, the proceeds of which will be used in connecting the distributing system of the corporation to the power stations of the New York Edison Co. The linking of the steam-distributing system to the Edison company's power stations has been made possible through an agreement recently entered into whereby the steam corporation will purchase from the Edison company large quantities of steam which will enable it to offer service in the Forty-second Street district. The New York (City) Steam Corp. supplies steam for power and heating purposes in the downtown financial district and in certain uptown sections, serving a large number of important buildings. Through the new arrangement it will be enabled to enlarge the scope of its services by entering the Times Square and Grand Central districts on a broad scale.

Figures showing the expansion of the steam power business of the corporation were furnished by James D. Hurd, president, in connection with arrangements for the issuing of stock, which show that for the calendar year 1921 the corporation sold 2,723,944,000 lb. of steam; in 1922, 3,065,521,000 lb.; in 1923, 3,660,885,000 lb.; and for the twelve months ended last May 31, 3,760,466,000 lb. of steam.

Drought on West Coast Gives Impetus to Storage

No sufficient reason exists for much of the foreboding prompted by the West coast drought, in the opinion of Major H. S. Bennion, assistant chief engineer of the Federal Power Commission, who has just returned from a trip through the Pacific states. Rainfall has its peaks and valleys, he points out, just as has the demand for electric power. When a trough happens to dip a little lower than has been the case for fifty years, there is no more reason to think the curve will stay at that point any longer than it did fifty years ago when there was a comparable drought.

Major Bennion understands how the serious difficulties occasioned by the drought are calculated to depress those who have to meet the situation, but as one who is not so close to the picture, he feels that there is no reason for serious concern. The apprehension uppermost in the minds of many of the power producers seems to be that involving the ability of the companies to finance their construction programs. From his contact with Eastern financial interests, Major Bennion feels certain that one bad year will not result in any impairment of credit.

The tendency toward public operation and the general acquiescence in paternalistic measures are vastly more significant than the drought or any possible impairment of credit, Major Bennion believes. He feels that state regulatory bodies are thoroughly capable of handling public-utility problems without so much attention from the federal government. In one way at least, he says, the drought is operating toward stabilization and expansion of the industry. It has given great impetus to the construction of storage works. This will prove a great boon to irrigation as well as to the generation of power.

Professors Taking Courses at Schenectady

The General Electric Co. is holding a conference of college professors at Schenectady, which will continue until Aug. 9. Study in the various departments, inspection trips and round-table conferences are included in the program.

Bureau of Mines Wants an Oil Shale Plant

An appropriation of $90,000 will be asked of Congress next December by the Bureau of Mines, for the purpose of establishing a plant in the field for the extraction of oil from shale, on which for several years the bureau has been engaged in laboratory experimentation. The estimate for this appropriation was submitted to the budget bureau several weeks ago and has been approved by General Lord, director of the budget, and by President Coolidge. The appropriation is to cover the construction of the plant, the land necessary for the plant, and the securing by purchase or otherwise, of the necessary shale or shale land.

Irrigation and Power Linked in the West

Headed by the Fresno Irrigation District, a group of irrigation districts on Kings River is making every effort to put through the proposed Pines Flat Reservoir. This reservoir will be of much importance to the San Joaquin Light & Power Co., since it will permit that company to store for power without regard for the irrigation rights in the valley below. The irrigation interests also are proposing to construct large storage on the San Joaquin in the Kerckhoff region.

The Merced Irrigation District hopes to put through promptly its project at the Exchequer dam site for which a license recently was issued by the Federal Power Commission.

The Oakdale Irrigation District is investigating a reservoir site in the Stockton region. The project involves a power development.

The Modesto Irrigation District has undertaken a departure in essaying to retail its own power. The irrigation district was not satisfied with the offer made it by the Pacific Gas & Electric Co. for its power. The experiment in retailing will be wa hed closely by other irrigation districts, it is declared.

Sale of Stokers for the Past Six Months

The Department of Commerce has just announced the following statistics on mechanical stokers according to reports received from 15 establishments.

Year and Month 1924	Establishments Reporting (Number)	Stokers Sold		Installed Under Fire-Tube Boilers		Installed Under Water-tube Boilers	
		Number	Horsepower	Number	Sq.Ft. of Heating Surface	Number	Sq.Ft. of Heating Surface
January	15	91	66,492	7	10,440	84	654,480
February	15	110	62,113	11	15,250	99	605,880
March	15	89	34,597	12	16,250	77	329,720
April	15	89	47,939	15	19,700	74	459,690
May	15	64	34,447	3	5,500	61	338,970
June	15	102	35,549	19	27,240	83	328,250
	—	545	281,137	67	94,380	478	2,716,990

Water-Power Projects

Sardinia Interested in Hydroelectric Plants—A hydro-electric scheme known as the Tirso project, involving the construction of an artificial lake and dam, has just been completed in Sardinia at a cost of 75,000,000 lire. Six more plants are to be constructed in various parts of the island within the course of the next five years. A second project on the Coghinas River, to cost 40,000,000 lire, is already under way, according to *Commerce Reports*, of a recent date.

Chile Water Power Project—According to recent announcement a new hydro-electric plant of 40,000 hp. built in the Andes Mountains has begun to send current into the City of Santiago, Chile. Two-thirds of the coal used in that country has been imported, and because of its ever-increasing cost, the development of hydro-electric stations is likely to be rapid.

In addition to the 40,000-hp. plant just completed, other plants are under construction, and the ultimate electrification of the trans-Andean railway is planned. The water-power resources of the Andes Mountains are adequate, engineers say, for a vast potential development.

Esthonia—Water-power resources of Esthonia, a Baltic province, up to 17,000 hp. have been utilized for mills, factories and power according to a consular bulletin recently issued. Work has also been started on a further 1,800-hp. station and the construction of a large hydro station at Narva on the Narova River is under consideration. This station would be capable of developing 62,000 hp. Another project on the Parnu River will develop 3,000 hp. The total water-power resources of Esthonia are estimated at about 170,000 hp., and the requirements of the country for agriculture, industry, lighting and transport at 100,000,000 kw.-hr. a year, according to recent press reports.

Ceylon Hydro Project Progressing. According to government reports, the Legislative Council of the Ceylon government has adopted, in modified form, a hydro-electric scheme for that island which will involve a capital outlay on the first stage of over 10,000,000 rupees, it is thought.

Mr. Preece, the consulting electrical expert engaged by the Ceylon government, expressed his opinion before the Legislative Council that as soon as the supply of electricity is available in and near Colombo at $0.05 (Singapore) or less per unit, there will be no difficulty in selling 25,000,000 to 30,000,000 units per annum. The proposed scheme cannot be completed for three to four years and by that time the actual demand that the hydro-electric scheme will be called upon to bear, he estimates, will not be less than 30,000 horsepower.

General details of this hydro-electric project are available for loan from the Electrical Equipment Division, Bureau of Foreign and Domestic Commerce, Washington, D. C.

Coming Conventions

American Ceramic Society. Ross C. Purdy, Lord Hall, Ohio State University, Columbia, Ohio. Summer meeting and tour. July 21 to Aug. 1st.

American Chemical Society. Dr. Charles L. Parsons, 1709 G St., N. W., Washington, D. C. Sixty eighth meeting at Cornell University, Ithaca, N. Y. Sept. 8-13.

American Electric Railway Association. James W. Welsh, 8 West 40th St., New York City. Meeting at Atlantic City, Oct. 6-10.

American Electrochemical Society. Dr. Colvin G. Fink, Columbia University, New York City. General meeting at Detroit, Mich., Oct. 2-4.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Fall convention at Pasadena, Calif., Oct. 13-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Autumn meeting at Birmingham, Ala., Oct. 13-15.

American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Fall meeting at Detroit, Oct. 23-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

Association of Iron & Steel Electrical Engineers, John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Annual meeting and exposition at Duquesne Garden, Pittsburgh, Pa., Sept. 15-20.

Illuminating Engineering Society. Norman D. MacDonald, 29 West 39th St., New York City. Convention at Briarcliff Lodge, Briarcliff Manor, N. Y., Oct. 27-31.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention at Detroit, Mich., Sept. 8-13.

Management Congress, First International. Prague, Czechoslovak, July 21-24.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **New England States Association** at Cambridge, Mass., July 24-26, formerly announced July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Wisconsin Association** at Fond du Lac, July 24-26. Vincent Todd, 25 Fourteenth St., Fond du Lac. **Minnesota Association** at Faribault, Minn., July 31, Aug. 1-2. C. A. Nelson, 800 22nd Ave., N. E. Minneapolis. **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids. **Pennsylvania State Association** at Grand Rapids, Mich., Sept. 8. J. N. Calvert, Union & Ridenour Ave., Crafton, Pittsburgh, Pa.

New England Water-Works Association, Frank T. Gifford, 715 Tremont Temple, Boston, Mass. Annual convention at Powers Hotel, Buffalo, N. Y., Sept. 23-26.

Universal Craftsmen Council of America. John F. Amos, P. O. Box 299, Rochester, N. Y. Meeting at Hotel Sherman, Chicago, Ill., Aug. 5-8.

Fisher Rapids Development — Development of a hydro-electric plant, with an ultimate capacity of 20,000 hp., with a 68-ft. head, at an estimated cost of $1,000,000, is indicated in the application for water rights on the Queets River in Jefferson County, Wash., by the Grays Harbor Railway & Light Co., of Aberdeen.

The company asks for 3,000 sec.-ft. of water to be diverted from the Queets River just below the confluence of the Clearwater River with that stream, and for reservoir rights on the stream. The development will be known as the Fisher Rapids power plant and will be developed in two units, the first of which will generate 10,000 hp.

Society Affairs

The N.E.L.A., Franklin T. Griffith, president, has announced the personnel of committees: The Technical National Section, H. P. Liversidge, chairman; C. F. Hirshfeld, L. M. Klauber and W. K. Vanderpoel, vice-chairman; Water Power Development, W. E. Creed.

National Research Council has announced the personnel of the Heat Transmission Committee as follows: W. H. Carrier, chairman of the executive committee; T. S. Taylor, vice-chairman; H. Harrison, Brunswick-Kroeschell Co., 30 Church St., New York City, secretary.

Personal Mention

R. D. Bean has recently been appointed chief engineer of The Brown Instrument Co., Philadelphia, Pa.

T. H. Hogg, formerly editor of *The Canadian Engineer*, has been appointed chief hydraulic engineer to the Ontario Hydro-Electric Commission, succeeding H. G. Acres, whose assistant he was.

H. G. Acres, chief hydraulic engineer for the Ontario-Hydro-Electric Commission has resigned that position. He will, however, be connected with the Commission in the capacity of consulting engineer.

Prof. Arthur Newell Talbot, of the University of Illinois, for his work as student and teacher, investigator and writer, and for his enduring contribution to the science of engineering, was presented with the Washington Award by the Western Society of Engineers recently.

Fred R. Low, editor of *Power* and president of the American Society of Mechanical Engineers, has recently been made an honorary member of the Institute of Mechanical Engineers, England. Mr. Low is at present in Europe, and has been attending the World Power Conference at Wembley, England.

Charles H. Herter, refrigerating engineer, has completed his work on the cold-storage plant for the Bronx Terminal Market of New York City and has taken up the duties of supervising and maintenance engineer for the Commonwealth and Washington Heights ice plants, New York City.

C. N. Lauer, general manager of Day & Zimmerman, Inc., has been elected president of the Philadelphia Engineers' Club.

Alex Dow, president of the Detroit Edison Co., was recently honored by the conferring upon him of the honorary degree of doctor of engineering by the University of Michigan, "in recognition of his distinguished career as a successful engineer, an administrator of large affairs, and a public citizen of high ideals."

Obituary

Frederick Fosdick, president of the Fitchburg Steam Engine Co., died suddenly during the night of July 7 at his home in Fitchburg, Mass. Mr. Fosdick was prominent in engineering, industrial and manufacturing circles in Massachusetts. His death came unexpectedly as he had been playing golf the day before and had attended a social affair during the evening.

Edward F. Latimer, for the last eleven years superintendent of construction of the Narragansett Electric Lighting Co., Providence, R. I., died suddenly recently at this home in Edgewood. Mr. Latimer was sixty-two years of age, and his earlier career included the operation of the plant of the Derby (Conn.) Gas Co., erection work for the McIntosh & Seymour Engine Co., electric railway work with the Waterbury (Conn.) Traction Co., four years with the United Gas Improvement Co. at Baltimore, Md., and a term of service with the Southern New England Telephone Co.

Business Notes

The Industrial Works, Bay City, Mich., announce the opening of a district office in the Monadnock Bldg., San Francisco, Calif., which is to be in charge of J. M. McGuire.

The General Electric Co. received orders amounting to $144,707,887 for the six months ending June 30. This is a decrease of 12 per cent compared with the corresponding period in 1923, when orders totaled $164,263,755.

The Armstrong Machine Works, Three Rivers, Mich., announces the acquisition of Otto J. Goeppinger, an engineer who has been closely associated with the paper industries. Mr. Goeppinger's services are offered for the solutions of problems involving the use of steam traps, one of the perplexing problems in drainage.

Trade Catalogs

Tanks, Storage—Conveyors Corp. of America, Chicago, Ill. Leaflet describing American cast-iron storage tanks for ashes, coal, etc.

Castings, Steel — American Manganese Steel Co., Chicago, Ill. Catalog No. 9, which is loose leaf, covers the entire range of production of castings made by this company. It is well illustrated with photos and drawings.

Refractories—Keystone Refractories Co., 120 Liberty St., New York City. Leaflet describing "Dura-Stix," a bonding mortar.

Insulation, Mica—The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Booklet describing the mica insulation furnished by this company.

Plants, Ice Making—Ophuls & Hill, Inc., 112 West 42nd St., New York City. Catalog describing with illustrations ice-making plants completed by this company during 1923.

Cranes and Hoists — The Euclid Crane & Hoist Co., Euclid, Ohio. Catalog, "Euclid Utility," describes, with illustrations, the many uses for which this equipment is serviceable.

Boiler Water Conditioning—Hagan Corp., Pittsburgh, Pa. Technical Paper No. 15-D, "The Hagan System of Boiler Water Conditioning," by H. A. Jackson, takes up the subject of scale formation in steam boilers and its prevention.

Stoker—Stanford Riley Stoker Co., 9 Neponset St., Worcester, Mass. "The Lateral Retort Stoker" is the title of publication No. 23, which describes this underfeed stoker. The catalog is illustrated with drawings and photos of the details as well as the assembled stoker.

Generator — Dominion Engineering Works, Ltd., Montreal, Canada. Bulletin No. 101 describes the Kaelin electric steam generator manufactured under the De Kermor patents. Tables of data including a comparison of coal-fired and electric steam plants are included.

Generating Sets—Engberg's Electric & Mechanical Works, St. Joseph, Mich. Catalog No. 800 gives a good description of the details of these alternating current generating sets and is well illustrated with drawings and photos. Tables of dimensions, weights and boxing are included.

Arches, Furnace—M. A. Hofft Co., 814 West Washington Ave., Indianapolis, Ind. Catalog "Increasing Today's Profits with Better Furnace Arches," presents clearly the outstanding features of the "National" suspended arch, manufactured by this company.

Compensated Draft—Hagen Corp., Pittsburgh, Pa. Technical Paper No. 14-R, "The Hagan System of Compensated Draft," by T. A. Peebles, gives an exhaustive discussion of a system of boiler control which could be practiced with any regulating apparatus having the required characteristics.

Trap, Steam — Armstrong Machine Works, Three Rivers, Mich. Catalog D, temporary edition No. 2, gives well-presented data in regard to these traps, although a larger and more complete edition is being prepared. Tables of capacities at different pressures, prices, and ordering and shipping information are included.

Brushes, Carbon—National Carbon Co., Inc., Cleveland, Ohio. A loose-leaf catalog describing the various types of brushes manufactured by this company including the tables giving grade, specific resistance, carrying capacity, peripheral speed, hardness, strength, contact drop, coefficient of friction and pressure recommended, has just been received.

Metal Bearing—Magnolia Metal Co., 113 Bank St., New York City. "The Magnolia Bearing Book" is divided into two parts: Part I takes up bearing metal alloys and their characteristics; Part II, hints for making lined bearings and making them give good service. The book is well illustrated and gives tables of bearing pressures and tests given the bearings made of this metal. Price $1.

Refractories—Walsh Fire Clay Products Co., St. Louis, Mo., "Refractory Facts; A Handbook of Essential Information About Fire-Clay Products," is not merely a catalog of this manufacturer, but a handbook filled with information of unusual value on clays, chemistry of clays and fire brick, as well as tables of useful information and many illustrations. Bound in stiff cloth-covered boards, a convenient size for the desk library, it is a creditable contribution to the technical literature on this subject.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	July 7, 1924	July 14 1924
Pool 1	New York	$2.90	$2.90
Smokeless	Columbus	2.35	2.35
Clearfield	Boston	2.20	2.00
Somerset	Boston	2.50	2 15
Kanawha	Columbus	....	1.60
Hocking	Columbus	1.85	1.85
Pittsburgh No. 8	Cleveland	1.95	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.75	1.75
S. E. Ky.	Louisville	1.75	1.75
Big Seam	Birmingham	2.10	2.10

FUEL OIL

New York—July 17, light oil, tank-car lots, 28@34 deg. Baumé, 5½c. per gal., 36@40 deg. 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis — July 8, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.55 per bbl.; 26@28 deg., $1.60 per bbl.; 28@30 deg., $1.65 per bbl.; 30@32 deg., $1.70; 32@36 deg., gas oil, 4.7c. per gal.; 38@40 deg., 5.5c. per gal.

Pittsburgh—July 9, f.o.b. local refinery, 30@40 deg., fuel oil, 5½c. per gal.; 36@40 deg., fuel oil, 5⅝c. per gal.; 34 deg., neutral, 8½c. per gal.

Dallas—July 11, f.o.b. local refinery, 26@30 deg., $1.30@$1.35 per bbl.

Philadelphia — July 10, 28@30 deg., $2.10@$2.163 per bbl.; 18@22 deg., $2.10@$2.16½; 13@16 deg., $1.78½@$1.848 per bbl.

Boston—July 14, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¾c. per gal., light oil, 28@32 deg. Baumé, 6¾c. per gal.

Cincinnati — July 15, tank-car lots, f.o.b. local refinery, 24@26 deg., Baumé, 4¾c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5⅝c. per gal.

New Plant Construction

Calif., Glendale—The City Commission, plans to vote bonds for $300,000 to finance the construction of an auxiliary power plant. A steam plant with turbine engine directly connected to a 2,500 k.w. generator to produce about 3125 h.p. is recommended. Other types may be considered.

Calif., Los Angeles—The City Council, plans an election to vote bonds for electric generating and distribution systems, estimated to cost approximately $16,000,000.

Calif., Porterville — Vandalia Irrigation District, will soon take new bids for irrigation works, pumping plants, pipe lines, etc. Former bids rejected. I. H. Althouse, is engineer.

Calif., Tracy—Banta Carbona Irrigation District, has voted $705,000 bonds for irrigation works for 14,000 acres of land involving construction of pumping plants, canals and laterals, etc. W. D. Harrington, chief engineer.

Conn., New Britain—State Board of Education, Hartford, will soon award the contract for the construction of a 15x40x40 ft. boiler house chimney and coal pocket, at Camp School, estimated to cost $40,000. W. F. Brooks, Gold & Lewis Sts., Hartford, architects, and A. Kellogg, 89 Franklin St., Boston, Mass., engineer.

Ga., Augusta—The Augusta-Aiken Railway & Electric Co., has authorized the J. G. White Engineering Corp., 43 Exchange Place, New York, to design and construct for their subsidiary the Georgia Carolina Power Co., addition to power plant on Stevens Creek near here., including power house; hydro electric apparatus, consisting of one 3125 h.p. turbine, and one governor and electric apparatus consisting of one 2700 kva. generator and switchboard.

Ill., Chicago Heights—Sisters of St. Francis will soon award the contract for the construction of hospital and power house, on 14th St., & Chicago Rd., estimated to cost $700,000. Smith, Garden & Martin, 104 S. Michigan Ave, Chicago, architects.

Ill., Schiller Park—The City Council, is receiving bids for water distribution system, including pumps, estimated to cost $100,000. Consor, Older & Quinlan, 140 South Dearborn St., Chicago, engineers.

Ky., Louisville—Office of United States Engineer, plans to purchase two 4 in. and one 6 in. suction steam driven direct connected centrifugal water pumps for dam No. 50 at Ford's Ferry.

Me., Wilton—The Wilton Woolen Co., G. F. Goodspeed, Manager, plans a hydro-electric plant, cost to exceed $40,000. Private plans.

Mass., Boston—Boston Elevated Railway Co., 31 St. James Ave., is receiving bids for a boiler plant and garage on Washington St., Forest Hills, estimated to cost $40,000. A. J. Blackburn, engineer, c/o owners.

Mass., Hopedale—The Draper Co., F. F. Butterworth, manager, is receiving bids for power house, air compressor unit, etc., cost to exceed $40,000. J. A. Stevens, 8 Merrimack St., Lowell, is engineer.

Mass., Roxbury, (Boston P. O.)—Metropolitan District Commission, Sewerage Division, 1 Ashburton Place, Boston, will construct new centrifugal pump plant for Ward Street station here, including 500 h.p. pump, estimated to cost $50,000. John A. Roblin, 1 Ashburton Place, Boston, engineer.

Mass., Springfield — Board of Public Works, Dept. of Engineering, will purchase complete equipment for pumping station on Washburn St.

Mass., West Newbury—Town Committee, J. D. King, Chairman, plans the installation of a municipal electric light plant, estimated to cost $40,000. Architect not selected.

Mich., Detroit—The Public Lighting Commission, will receive bids until July 28, for complete powdered coal equipment for three unit steam electric power plant on Morrell St. Smith, Hinchman & Grylls, 800 Marquette Bldg., engineers.

Minn., Litchfield—The city, M. Mortenson, Recorder, is receiving bids for ash removing and coal handling machinery for power plant. L. P. Wolff, 903 Globe Bldg. and E. D. Jackson, 403 Endicott Bldg., St. Paul, engineers.

Mo., Mountain Grove—E. H. Williams, is having plans prepared and will receive bids about Aug. 1, for 50 miles of distribution lines, and a power plant of 500 to 800 h.p. capacity. Alexander Engineering Co., 517 Woodruff Bldg., Springfield, engineers.

Mo., St. Louis—T. L. Leonard Electric Co., 1706 Olive St., will purchase one, 50 hp. oil burning engine.

Mo., St. Louis.—Union Electric Light & Power Co., 12th & Locust Blvd., has awarded the contract for the construction of a 63x50x67 ft. power plant, to Fruin-Colnon Construction Co., Merchants Laclede Bldg.

Mo., St. Louis—U. S. Treasury Department, Supervising Architects Office, Washington, D. C. will receive bids until Aug. 5, for furnishing and installing complete, one electric motor driven pump and one motor driven air compressor in post office here.

Mo., Washington — The City has voted $60,000 bonds for water works, including engines, pumps, etc. W. B. Rollins & Co., 3945 Benton Boulevard, engineers.

Mo., Willow Springs — Willow Springs Light & Power Co., will soon receive bids for an electric light and power plant to replace one recently destroyed by fire. Alexander Engineering Co., Springfield, engineers. Estimated cost $50,000.

Neb., Omaha—Nebraska Power Co., c/o J. C. Davidson, has awarded a contract to the Pheonix Utility Co., 71 Broadway, New York, for a 2 story 59x253 ft. addition to power house.

Nev., Fallon—The City Council will receive bids until July 30, for the construction of an electric generating station. Alternate bids to be taken on (a) 2 Diesel or Semi-Diesel engines, one 150 h.p. and one 250 h.p., each direct connected to individual 2,300 v., 60 cycle, 3 phase a.c. generator and exciter to utilize full rated power of engine without overload, (b) two Diesel or semi-Diesel engines, one 200 h.p. and one 300 h.p. d.c. generators as above, only correspondingly larger size.

N. J., Lavalette—The Borough Council, H. A. Whitelock, Clerk, will install water supply system, pumping station, etc., estimated to cost $100,000.

N. Y., Buffalo—Klinck & Schaller, Inc., 624 Babcock St. awarded a contract to Metzger Contracting Co., 676 Genesee St., for addition to packing house and cold storage plant. Cost to exceed $42,000.

N. Y., Buffalo—W. Wiegel, 144 Humbolt Parkway, had plans prepared and will soon receive bids for the construction of an ice rink, estimated to cost $500,000. Plumer & Mann, 700 Main St., are architects. Ice making machinery will be purchased.

N. Y., Hudson—C. A. Van Duesen Co., is having plans prepared and will receive bids about Aug. 1, for the construction of a 5 story, 95x133 ft. pork packing and wholesale grocery warehouse; and a 30x50 ft. boiler house. Estimated cost $250,000. Equipment will be required for boiler house, also bar rail conveying machinery, and refrigerating equipment etc., for warehouse. Monks & Johnson, 99 Chauncey St., Boston, Mass., architects and engineers.

N. Y., Staten Island—The Staten Island Edison Corp., St., George, has awarded the contract for design and construction of sub-stations at Livingston, Eltingville, Atlantic, Arrochar, Clifton Junction, and Dongan Hills and St. George; also power plant addition at Livingston including the installation of 15,000 kw. unit with necessary auxiliaries, to J. G. White Engineering Corp., 43 Exchange Pl., New York.

N. Y., Wende—Erie County, Board of Supervisors, Room 29, City and County Hall, will receive bids until July 22, for the construction of a steam boiler plant, including boilers, piping and steam duct, for the Erie County Penitentiary.

N. C., Durham—R. W. Rigsby, City Manager, has awarded a contract to the Hardaway Contracting Co., Columbus, Ga., for erection of dam on Flat River, power house, road and pipe lines, cost $934,812. The work is part of a $2,000,000 water and power development, to supply the city with water, the surplus will be used to generate electric power. Equipment necessary to develop 1,500 kw. will be installed, and a 22,000 volt transmission line, eleven miles in length will be built.

O., Cleveland—The Cleveland Electric Illuminating Co. Illuminating Bldg., has awarded a contract for the construction of foundation of a power plant at 1839 Lakeside Ave., total estimated cost $300,000. E. J. Cook, Illuminating Bldg., is engineer.

Ore., Klamath Falls—The California-Oregon Power Co., is having plans prepared for diversion dam, tunnels and power house with two 20,000 hp. units. Estimated cost $3,000,000. Private plans.

Pa., Harrisburg—Department of Property & Supplies, Capitol Bldg., has awarded a contract to T. W. Sprayer, Harrisburg, for a power plant, estimated to cost $144,000. Arnold W. Brunner, 101 Park Ave., New York, is architect and engineer.

Pa., Kingston—Luzerne County Gas & Electric Co., has awarded a contract to Stone & Webster, Inc., 120 Broadway, New York, N. Y., for the design and construction of a steam turbine station, estimated to cost $5,000,000.

Pa., Monessen—St. Leonards R. C. Congregation, and C. Strong, Keystone Bldg., Pittsburgh, Architect, is receiving bids for boiler house in connection with convent and school, estimated to cost $315,000.

Pa., Phila—Lehigh Silk Hosiery Mills, Inc., D & Ontario Sts., has awarded the contract for the construction of a 2 story, 35x200 ft. boiler and dye building on Jasper and Butler Sts., to Harry Brockelhurst, 512 W. Norris St. The contractor is taking sub-bids.

Pa., Pittsburgh—The Duquesne Light Co., Chamber of Commerce Bldg., has awarded a general contract for a 2 story 65x120 ft. sub-station on Penn. Ave., to Dwight P. Robinson & Co., Penn. Ave., & 13th St. estimated to cost $150,000. R. Painsford, 435-6th Ave., is engineer.

Pa., Seward—Penn. Public Service Corp., has authorized Dwight P. Robinson & Co. Inc., 125 East 46th Street, New York, to design and construct an extension to the power plant here to consist of the installation of two new boilers equipped with preheaters and fans, one new stack and new boiler feed pumps. The stoker equipment will be exact duplicate of that already installed.

Tenn., Knoxville—The Southern Railway Co., has awarded a contract to The Foundation Company, 120 Liberty St., New York, for design and construction of the John Sevier Yard near here. Plans include a power house.

Tenn., Trezevant — The City Council, plans to build a municipal light and power plant. Estimated cost $40,000.

Tex., Brownwood — Brownwood Ice & Fuel Co., is receiving bids for ice plant and cold storage system, estimated to cost $50,000. H. Mount, is architect.

Wis., Kimberly—The City, H. Langenburg, Clk., is receiving bids for reservoir and pump house, estimated to cost $15,000. A. E. McMahon, Menasha, is engineer.

Wis., Friendship—The Friendship Electric Light & Power Co., will build a hydro-electric plant by day labor. Bids to be received on equipment. L. A. DeGuere, Wood Block, Wisconsin Rapids, Engineer.

Wash., Seattle—Puget Sound Power & Light Co., has been granted a permit to use 4,000 cu.ft. per second of water from Baker River for power purposes, and will construct a tunnel, dam, pipe line and power house, estimated to cost $3,500,000.

Ontario—King & West Gwillimbury Townships, E. J. Evans Bradford, Clerk, plans drainage system, to include pumping. 7,500 acres of swamp land will be drained. Estimated cost $50,000. Want information and prices on all equipment.

Ontario, Toronto—The City, W. W. Hietz, Mayor, City Hall, will receive bids until August 19 for the supply and erection of a 400 hp. power steam turbine. R. C. Harris, City Hall, is engineer.

Que., Lac Bouchette—La Cie Electrique Lac Bouchette, Ltd., contemplates building a small dam and power house.